3.2 Water Resources and Geochemistry

The study area for direct, indirect, and cumulative impacts for water resources is described in the following paragraphs. The study area and cumulative effects study area for wetlands and waters of the U.S. are the same as those described for vegetation resources in Section 3.4.

3.2.1 Affected Environment

3.2.1.1 Hydrologic Setting

The general topographic and physiographic features of the region are discussed in Section 3.1.1.1, Physiographic and Topographic Setting, and are shown in **Figure 3.1-1**. The project area straddles the divide between two designated groundwater basins: Crescent Valley Hydrographic Area and the Grass Valley Hydrographic Area (NDWR 2005). The project area is located approximately 1.5 miles west of the Pine Valley Hydrographic Area. The boundaries of these hydrographic areas relative to the project boundary are shown along with regional physiographic features in **Figure 3.2-1**. Mount Tenabo marks the intersection of these three hydrographic basins, separating Crescent Valley to the north, Grass Valley to the south, and Pine Valley to the east. Both the Crescent Valley and Pine Valley hydrographic areas are part of the Humboldt River basin; Grass Valley is a closed basin.

The Hydrologic Study Area (HSA) encompasses the Crescent Valley Hydrographic Area, northern portion of the Grass Valley Hydrographic Area, and westernmost portion of the Pine Valley Hydrographic Area (**Figure 3.2-1**). The HSA was used as the basis for describing existing conditions in the region encompassing the Cortez Hills Expansion Project, for evaluating potential direct and indirect impacts to surface and groundwater resources resulting from the proposed project, and for evaluating cumulative impacts. Within the HSA, elevations range from 9,680 feet amsl at Mount Lewis in the northern Shoshone Range, to approximately 4,700 feet amsl in Beowawe. At an elevation of approximately 9,160 feet amsl, Mount Tenabo in the Cortez Mountains is the highest point in the eastern part of the HSA. In the project area, elevations range from approximately 6,800 feet amsl on the slopes of Mount Tenabo to approximately 4,760 feet amsl in the lower portions of Crescent Valley (see **Figure 3.2-1**).

The climate in the HSA is arid with most precipitation occurring in the months of March through May. Throughout the region, precipitation varies widely between seasons and years as well as with elevation. The variation in average annual precipitation with elevation for weather stations in the region is summarized in **Table 3.2-1**. On the valley floor, the mean annual precipitation at the existing Cortez Mine is approximately 8 inches, with seasonal maxima in the summer months and minima during the winters. Similar data are reported by the Western Regional Climate Center for the Beowawe meteorological station north of the project boundary (Geomega 2006e). Regional data indicate that at elevations above 5,000 feet amsl, mean annual precipitation generally increases by 5 to 10 inches above the amounts received on the valley floors (Geomega 2006e).

Table 3.2-1
Mean Annual Precipitation at Selected Regional Sites

Station Location	Approximate Distance/Direction from Project Area Center	Approximate Elevation (feet amsl)	Measured Mean Annual Precipitation[1] (inches)
Beowawe	27 miles, north-northeast	4,700	8.8
Beowawe-University of Nevada Ranch	18 miles, south	5,740	11.0
Eureka	45 miles, southeast	6,540	12.1

[1] Period 1971 to 2000.

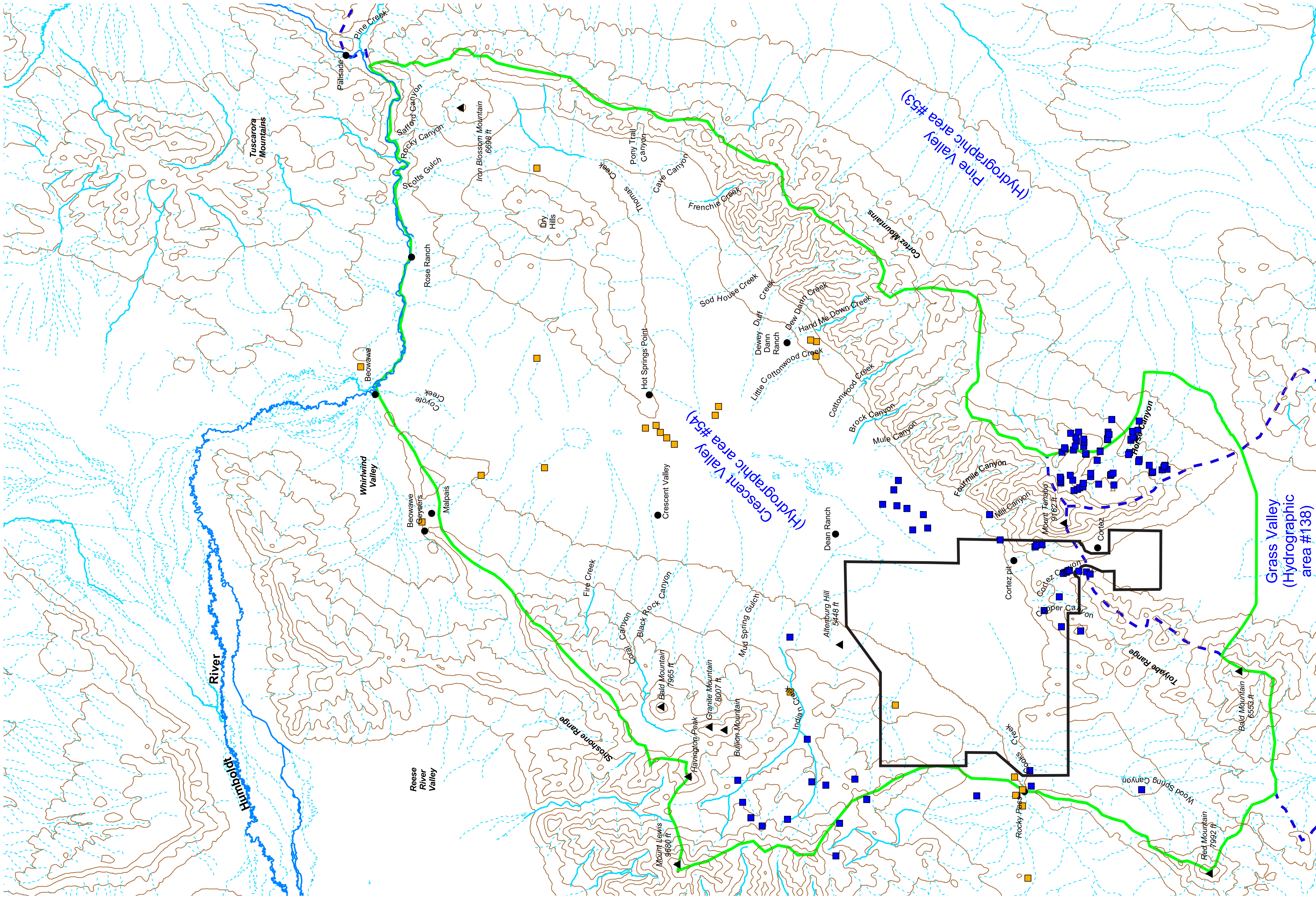
Source: Geomega 2006e.

Evaporation rates vary with a number of factors, of which temperature, wind speed, relative humidity, and solar radiation are primary. Based on year-round regional data from Fallon, Nevada, the mean annual pan evaporation is estimated to be 51.2 inches at the Beowawe – University of Nevada Ranch station south of the HSA (Geomega 2006e). Pan evaporation at the project area is probably somewhat greater due to its lower elevation and higher average temperatures (Geomega 2006e). With a typical pan coefficient of 0.7, the mean annual evaporation from a free water surface would be approximately 36 inches. Based on pan evaporation measurements, USGS investigations estimated an open-water evaporation rate of 4.2 feet (50.4 inches) per year for the middle Humboldt River basin (Berger 2000, as cited in Geomega 2006e). Average annual evapotranspiration, which includes the effects of vegetation, the ground surface, and other factors, may differ substantially from this estimate as discussed in Section 3.2.1.3.

3.2.1.2 Surface Water Resources

As is typical in the Basin and Range Province, the project region is dominated by mountain block watersheds that drain onto broad alluvial fans and valley fills. Perennial, intermittent, and ephemeral stream reaches occur in the bedrock-controlled mountain drainages, and flows typically dissipate into the fans along the valley margins or drain toward playas near the basin centers.

Surface water features and major drainages in the HSA are presented in **Figure 3.2-1**. The HSA is bounded on the north by the Humboldt River. Within Crescent Valley and Grass Valley, surface water resources primarily consist of streams that generally drain from the mountain watersheds toward alkali flats (playas) in the lowermost valley areas. A few small artificial ponds are located along stream channels. On the valley floor, the playas are intermittently wet from runoff. Most of the land area of Crescent Valley rarely, if ever, contributes surface water to the Humboldt River, due to a low topographic divide just south of Beowawe and other watershed divides near Iron Blossom Mountain. East of the project boundary, Pine Valley generally trends northward, paralleling Crescent Valley. The portion of Pine Valley included within the HSA is known as the Horse Canyon area and includes headwater tributaries that drain the eastern slope of the Cortez Mountains near Mount Tenabo. Its major channel, Pine Creek, is perennial over most of its length. Springs and seeps are common along its tributaries, such as Horse Creek and Willow Creek. Pine Creek drains to the Humboldt River at Palisade, west of Carlin, Nevada (see **Figure 3.2-1**).



Legend:

- Project Boundary
- Hydrographic Basin Boundary
- HSA and Water Resources CESA
- Streams Dashed Where Intermittent
- Elevation Contours: 500-foot Interval
- Monitored Seeps and Springs
- Geothermal Springs

N

0 3 6 Mile

Source: Geomega 2006e. Note: Hydrogeographic area numbers from Rush 1968.

Cortez Hills Expansion Project

Figure 3.2-1

Perennial Streams, Springs, and Seeps

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The Humboldt River flows along the northern edge of the Crescent Valley Hydrographic Area for a distance of approximately 17 miles (**Figure 3.2-1**). At Palisade, the river is at an elevation of 4,825 feet amsl (Maurer et al. 1996). Drainage from Safford Canyon enters the river at Barth. Additional drainage enters from Rocky Canyon, approximately 2.5 miles to the west of Safford Canyon. The valley is narrow between Palisade and Rocky Canyon, and the river channel is incised into bedrock over much of that reach. From Rocky Canyon, the Humboldt River flows west toward Beowawe across the northern end of Crescent Valley. In this reach, the channel widens and meanders, and the gradient becomes less steep. The river leaves the valley at the gap near Beowawe, where it turns to the north. At Beowawe, the river is at an elevation between 4,680 and 4,690 feet amsl (Plume 1996).

Streams

Precipitation and geologic conditions in the study area are such that perennial stream flow only occurs in a few isolated stream reaches. Streamflows in the HSA primarily occur as intermittent flows from isolated springs, short-term seasonal runoff from snowmelt or winter storms, or as ephemeral flow from intense, infrequent thunderstorms. Numerous drainages leave the mountain fronts and cross alluvial fans. Flows typically dissipate on the fans themselves or farther downgradient in the valley floors. When water does reach the valley floor during larger runoff events, it is soon taken up by evapotranspiration and seepage into valley-floor sediments.

Based on existing data, it is likely that isolated stream reaches are perennial during years of normal and above-average precipitation. A number of springs occur higher in the bedrock-controlled mountain watersheds and also where the mountain fronts transition onto alluvial fans. Perennial flow and/or seasonally ponded water are most likely to occur over short stream reaches or downstream of perennial springs. In the portion of the HSA draining westward from the Cortez Mountains, such flow features may exist in portions of Thomas Creek, Frenchie Creek, Sod House Creek, and Brock Canyon (Geomega 2006e). The Thomas Creek drainage is in the relatively narrow northeastern arm of Crescent Valley (**Figure 3.2-1**). It is fed by a number of creeks and springs that issue from the Cortez Mountains on the east and from comparatively shallow bedrock features associated with Iron Blossom Mountain on the north and west. A number of springs discharge to Thomas Creek 1 or 2 miles south of its headwaters. In August 1992, flow in this area was estimated at 5 to 20 gpm (Geomega 2006e). Sod House Creek extends 6 miles to Thomas Creek, and flowed 30 to 50 gpm in August 1992. A small reservoir is located at the entrance to Frenchie Canyon. In August 1992, flow upstream of the reservoir was measured at 200 gpm (Geomega 2006e). In Brock Canyon, streamflow at the bedrock/alluvium contact was estimated in August 1992 to be 1 to 5 gpm (Geomega 2006e). The annual precipitation in 1992 was well above average at Battle Mountain, but generally appears (due to missing data) to be below average at Beowawe, and was only about two-thirds of average at Eureka and Beowawe – University of Nevada Ranch (Western Regional Climate Center 2006). It is likely that these streams flow at least during spring and summer during average years.

No other channels draining westward from the Cortez Mountains in the HSA have recorded streamflows. Based on review of aerial photographs, short perennial or intermittent stream reaches also may occur in Mill Creek, approximately 2 miles northeast of the proposed Cortez Hills Pit, and in the headwaters of Cave

Creek, Duff Creek, Hand-Me-Down Creek, and associated side drainages upgradient of the alluvial fan system.

In the Pine Valley portion of the HSA, numerous headwater tributaries to Pine Creek form on the east and southeast-facing slopes of the Cortez Mountains. Willow Creek, as well as Horse Creek and its tributaries in the Horse Canyon area east of the project area, are steep channels fed by runoff and springflow. In August 2005, short channel reaches contained flows of 5 to 12 gpm, largely resulting from springflow contributions that then seeped into alluvial deposits a short distance downstream (Geomega 2006e). Isolated flowing reaches in the Horse Creek drainage also were identified during August 2005. Flows in these isolated tributary reaches ranged from approximately 10 to 60 gpm before surface flows were lost to infiltration or evapotranspiration. Total precipitation amounts for 2005 were well above average to the north at Battle Mountain and Beowawe, but were average to the south at Beowawe – University of Nevada Ranch (Western Regional Climate Center 2006). However, precipitation rates in the late winter of 2004 and spring of 2005 generally were well above average. Therefore, there is some question as to whether baseflows in these reaches represented mean annual conditions. It is likely that the observations recorded greater flow rates and longer seasonal flow durations than the numerical average; however, conditions in arid-land surface water systems normally vary widely.

Based on aerial photograph inspection and the occurrence of riparian vegetation, Willow Creek is intermittent and possibly perennial downstream of a point approximately 1 mile west-northwest of the corner of Townships 27 and 26 North, Ranges 48 and 49 East, just outside the HSA approximately 3.5 miles east of Mount Tenabo. On a similar basis, Horse Creek is intermittent and possibly perennial along a 1.5-mile reach at the base of steeper alluvial fan deposits in Sections 19 and 30, T26N, R49E, above an elevation of approximately 5,900 feet amsl. This reach is downstream of a series of springs and is within the HSA extending into Pine Valley. Horse Creek is probably intermittent below this reach due to seepage losses from the channel. Intermittent or ephemeral reaches and tributaries occur upstream in both the Horse Creek and Willow Creek drainages. In the Dry Hills south of Horse Canyon, a few drainages were observed to have pools or discontinuous flows in August 2005 (JBR 2006c).

Elsewhere in the HSA, smaller unnamed canyons on the northwest and southeast flanks of the Toiyabe Range drain into the southern part of Crescent Valley or into Grass Valley, respectively. The majority of streams draining the Toiyabe Range are ephemeral. Intermittent flows may occur in isolated stream reaches within larger watersheds such as the Wood Springs drainage to the west, the House Spring and Wenban Spring drainages north of Bald Mountain, or in unnamed creeks that drain the mountain slopes southeast into Grass Valley. Small surface flows of 1 to 3 gpm were reported in mid-September 1992 in the drainage upstream of Wood Spring (Geomega 2006e). Unnamed creeks below the 5,600-foot elevation were reported at that time to be dry. Copper Canyon also drains this area to the north. Flows in Copper Canyon are subsequently described in the project area discussion.

Along the western side of the HSA, major streams draining the Shoshone Range include the Rocky Pass drainage, Indian Creek, Mud Spring Gulch, Fire Creek, and Corral Canyon (**Figure 3.2-1**). Based on aerial photo review and collected data, perennial and/or intermittent flows are likely to occur in the Rocky Pass (Cooks Creek), Indian Creek, and Fire Creek drainages. Numerous smaller drainages such as Black Rock Canyon also drain to the alkali flats. Cooks Creek flows from Carico Lake to Crescent Valley through Rocky

Pass. Reports from 1992 indicate surface flow rates in this channel of 100 to 200 gpm (Geomega 2006d). Underflow from the creek forms perennial springflow at Rocky Pass. No flow records exist for Corral Canyon, Black Rock Canyon, or Mud Spring Gulch. Fire Creek was flowing at 16 gpm in late September of 1992, and Indian Creek was flowing at approximately 10 to 400 gpm (increasing downstream with tributary inflows) in August 1992 (Geomega 2006e). In the lower part of Indian Creek, where it leaves the mountains and discharges onto the alluvial fan, more recent monitoring between 1997 and 2004 indicates streamflows ranged from approximately 10 to 14,500 gpm, with an average flow of approximately 1,700 gpm (Geomega 2006d). At this monitoring location in 2006, flow in Indian Creek was approximately 175 gpm in September, and increased to approximately 210 gpm in December (JBR 2006b). Based on these conditions, Indian Creek is perennial over much of its length. Eventually, all flow from these watersheds seeps into the valley fill or evaporates on the playas. At the northern end of the Shoshone Range, Coyote Creek drains to an irrigation canal system and eventually to the Humboldt River (**Figure 3.2-1**).

In the proposed project area, major watersheds that drain toward Crescent Valley from the Toiyabe Range and Cortez Mountains include Copper Canyon, Cortez Canyon, Mill Canyon, and Fourmile Canyon (**Figure 3.2-1**). These streams are assumed to have intermittent flows, with the exception of potential perennial reaches in Mill Canyon as discussed below. Quarterly spring and seep investigations have been conducted in the project area by JBR, and streamflows have been noted and/or measured during this program.

Under these conditions of relative high precipitation, flows in Copper Canyon varied from zero up to 30 gpm, depending on position along the channel, the presence of springs and seeps, and the number of contributing tributaries. Flows disappeared and re-emerged at irregular intervals in the tributary channels, but were nearly always present in the main channel (JBR 2005c). Two small ponds and a number of wetlands occur in Copper Canyon. Flows were intermittently present at the mouth of the canyon in early June 2005.

Cortez Canyon drains northwest (from the western boundary of the project area) toward Crescent Valley. No flow records exist for Cortez Canyon proper. In 2002, small unmeasurable flows were reported in summer at the Cortez Canyon spring located on a side slope near the head of the drainage (JBR 2002b). However, no flow was visible farther downstream in the channel proper during a site visit by the BLM EIS team in May 2006. In 2005, small flows were observed in tributary drainages in the northernmost Toiyabe Range (JBR 2005c). These flows were discontinuous along the channels at rates generally less than 5 gpm. Below the confluence of the upper drainages, flows reached 7 to 10 gpm before joining the main Cortez Canyon channel. Flow at the mouth of the canyon was estimated to be 10 to 12 gpm at the end of May, but was absent in early June (JBR 2005c).

In the northeastern part of the study area (approximately 1 mile north of the proposed Cortez Hills Pit boundary, near the proposed North Waste Rock Facility), some isolated channel segments do contain seasonally-ponded water as a result of near-surface groundwater contributions. In some years, these sections may hold water year-round. These features, referred to by JBR as the Northeast Corner seeps and springs, are described below. In this same general area but farther east, Mill Canyon runs for approximately 4 miles northward into Crescent Valley from Mount Tenabo. Elevations in the drainage range from approximately 7,700 feet amsl to 4,800 feet amsl at the base of the alluvial fan. On April 1, 1992, a streamflow estimate of 20 to 50 gpm was made in Mill Canyon (Geomega 2006e). Seasonal precipitation was well below average at that time (Western Regional Climate Center 2006). Observations by the BLM EIS team during a site visit to the mouth of Mill Canyon in late May 2006 indicated that this stream was flowing and is probably perennial during periods of average or above-average precipitation based on the thick willows and other riparian vegetation along the drainage corridor.

Fourmile Canyon is approximately 6 miles long, with elevations ranging from approximately 7,200 feet amsl in the upper reaches to 4,800 feet amsl on the alluvial fan. No flow records are available for this drainage. Observations by the BLM EIS team during a site visit to the mouth of Fourmile Canyon in late May 2006 indicated that although the stream reach was flowing, it is unlikely that the stream is perennial due to the general lack of riparian vegetation along the drainage corridor.

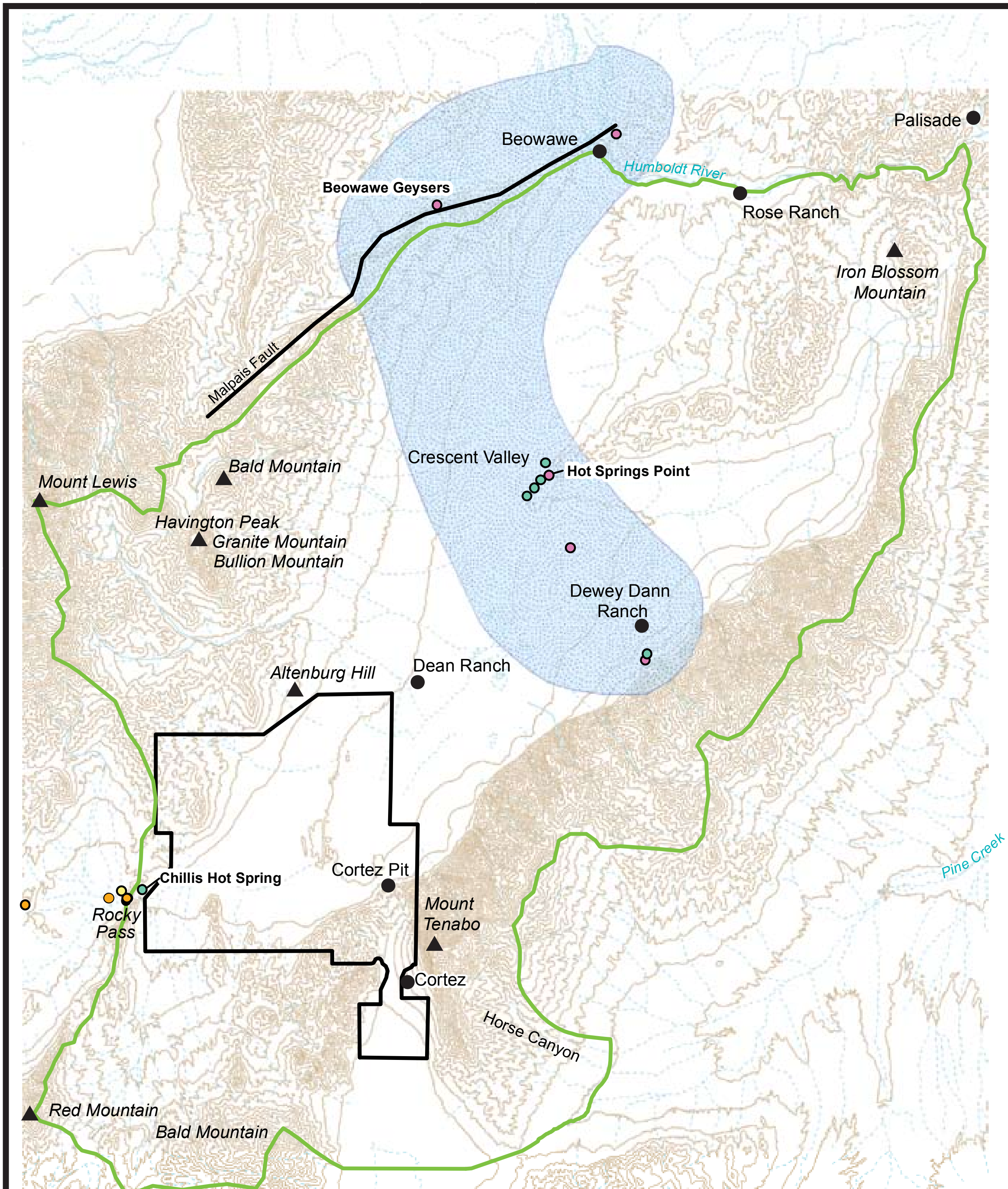
In drainages that flow southeastward from the Toiyabe Range into Grass Valley, investigations in May 2005 indicated that flows generally ranged from approximately 0.5 to 5 gpm (JBR 2005c). These flows are fed by springs or seeps, and they emerge or disappear at irregular intervals along the stream courses. Flows ranging from 5 to 10 gpm on the alluvial fan were identified in a channel that drains to Grass Valley across Section 24, T26N, R47W in the very southern part of the project boundary.

Seeps and Springs

Multiple springs and seeps occur in Crescent Valley and the HSA. Three of the spring systems in Crescent Valley are thermal springs; the remainder are cold springs (BLM 1996a). The largest spring system in the valley is at Hot Springs Point located at the southern extremity of the Dry Hills (**Figure 3.2-2**). This system consists of five springs with temperatures ranging from 79 to 138 degrees Fahrenheit (°F) (26 to 59 degrees Celsius [°C]) (WMC 1992). Other hot springs in Crescent Valley are the Chillis Hot Springs in Rocky Pass, which has a water temperature of 102°F (39°C), and an unnamed spring near the base of the Cortez Mountains west of Hand-Me-Down Creek (BLM 1996a). A major geothermal system, the Beowawe Geysers, is located in Whirlwind Valley, adjacent to the HSA.

The thermal springs at Hot Springs Point (**Figure 3.2-2**) issue from fault zones in the siliceous bedrock at the alluvial bedrock interface (Muffler 1964; WMC 1992). The Chillis Hot Springs issue from the Caetano Tuff close to the alluvial bedrock contact (WMC 1992). Muffler (1964) mapped the hot spring at Hand-Me-Down Creek (also known as the Dewey Dann spring), associated with the Hot Springs Point geothermal system, near the contact of the alluvium and the Pony Trail Group intrusions that occur along the Crescent Fault. The source of the hot spring is thought to be within the intrusions.

The Beowawe geothermal system (**Figure 3.2-2**) is associated with the Malpais fault system, a range front normal fault. Meteoric water is heated at depth and circulates upward along the range front fault system. On the basis of measured geothermal gradients, a depth of 4.3 miles is required to attain the measured temperatures (Struhsacker 1986). Mauer et al. (1996) reported that the source of thermal water at Beowawe could be restricted to the area contained in Whirlwind Valley. The surface expression of the geothermal system consists of a 215-foot-high and 1-mile-long opaline sinter terrace produced by hot spring and natural



Legend

- Project Boundary
- Water temperature greater than 40°C
- Elevation Contours (200-foot interval)
- Streams Dashed Where Intermittent
- HSA
- Warm spring less than or equal to 37°C
- Hot spring greater than 37°C
- Thermal Spring (20-50°C)
- Thermal Spring (greater than 50°C)

N

0 2.5 5 Miles

Source: Geomega 2006e.

Cortez Hills Expansion Project

Figure 3.2-2
Geothermal Resources

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geyser activities. A maximum downhole temperature of 415°F (213°C) has been recorded in the area. The steam plume and hot water geyser that vents continuously at the terrace is not a natural geyser but a free-flowing uncapped geothermal well (Struhsacker 1986).

In Crescent Valley, 68 seeps and springs were surveyed by JBR in 1993 (JBR 1993). These springs are located in the southern part of Crescent Valley. The survey did not locate all of the springs in the valley. Most were hillside seeps and springs associated with wet meadows and riparian areas below 6,000 feet amsl, classified as palustrine-type wetlands. Others were found emanating from the beds of drainages, classified as riverine-type wetlands.

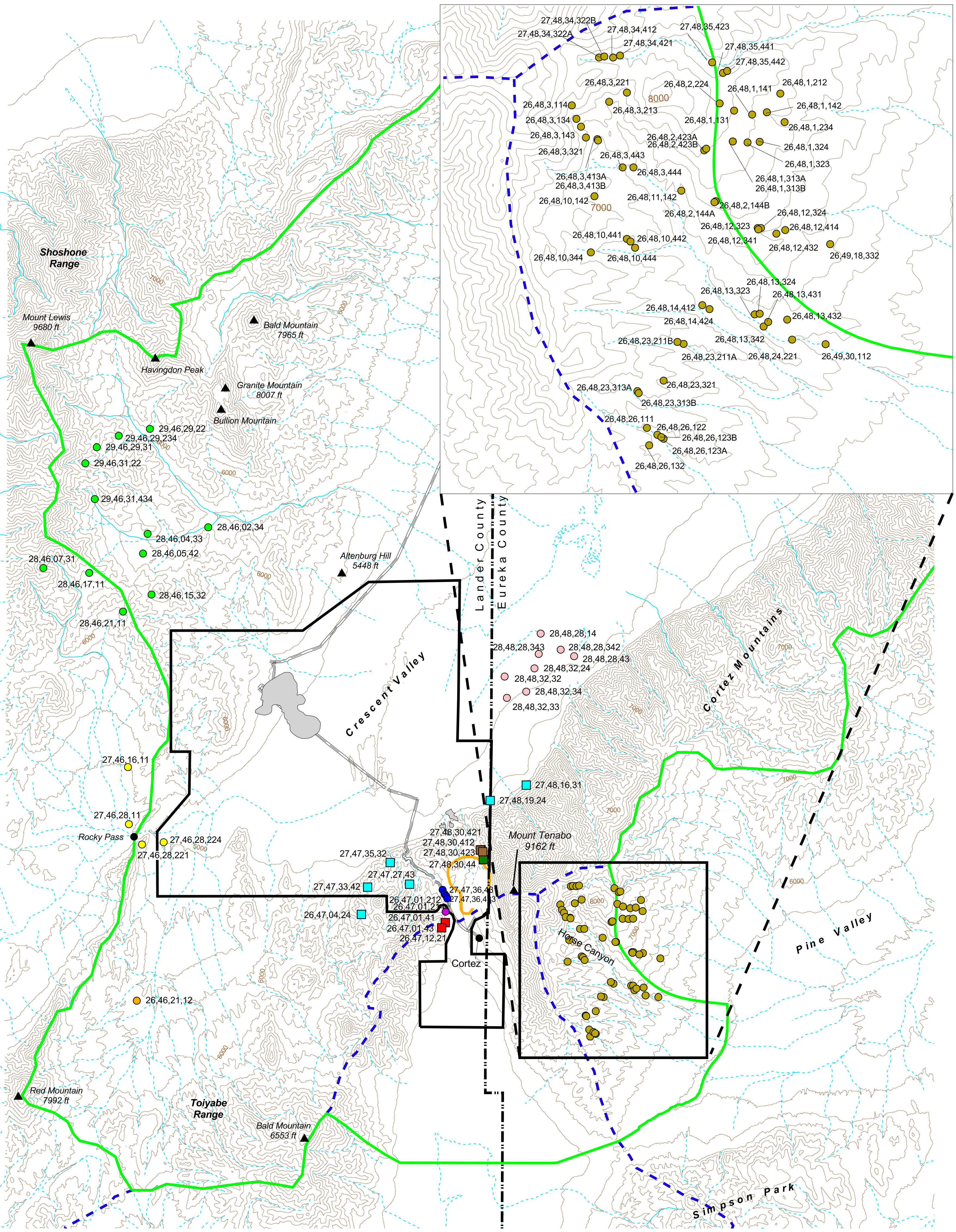
Of the 68 sites surveyed, 24 were selected for quarterly monitoring, and 7 were selected for semiannual monitoring. Of the monitored springs, 4 are in the Rocky Pass area, 6 are in the Toiyabe Catchment area, 12 are in the Shoshone Mountains west and northwest of the project area, 8 are located in the east valley, and 1 is in a peripheral area in the Toiyabe Range. Results of the monitoring program are discussed in the report for the Cortez Gold Mines Pipeline Project Seep and Spring Monitoring: Summer Quarter 2005 (JBR 2005b).

For discussion purposes, springs and seeps located within the project vicinity are grouped into six locales that include: the Toiyabe Catchment, Cortez Canyon spring, Northeast Toiyabe seeps, Cortez Canyon seeps, Northeast Survey Area seeps, and Northeast Corner seeps (**Figure 3.2-3**).

The Toiyabe Catchment group is composed of six individual springs, four of which are within the Toiyabe Range and two of which are in bedrock at the foot of the Cortez Mountains on the margin of Crescent Valley (Geomega 2006e). One of the latter is at the foot of Mill Canyon. Water sources for these springs are believed to originate from isolated fault-blocks, which are recharged from snowmelt and precipitation. A number of smaller isolated springs occur in the Toiyabe Range to the west and south of the HSA. Monitoring data for the six numbered springs in the group have been gathered from 1996 through 2006. These data indicate that spring flows vary widely throughout the year and between locations (see **Table B-1** in Appendix B). Generally, flows ranged from approximately 0 to approximately 112 gpm, with higher values typically observed in the late spring.

The Cortez Canyon spring flows from a water-filled adit west of the Cortez Canyon road (Geomega 2006e). A trickle of flow was observed in June and August 2002 (see **Table B-1** in Appendix B). Four spring-seep emergences were observed in Cortez Canyon itself (see **Figure 3.2-3**). These were all dry in August 2002 but flowed at less than 1 gpm in March 2000 (Geomega 2006e). Observations in June 2002 were complicated by drilling discharges.

The Northeast Toiyabe seeps consist of two seeps on the flank of the range above Grass Valley. The second and larger of the two exhibited a flow of 1 gpm in March 2000, but was dry in June and August 2002. No flow was observed at the smaller seep in June and August 2002. A similar condition was observed at the Northeast Survey Area seep in June and August 2002.



Legend

- Project Boundary
- Pipeline Pit
- Proposed Cortez Hills Pit
- HSA
- Hydrographic Basin Boundary
- Project Area
- Elevation Contours: 200 foot interval
- Roads
- County Line

Spring locations
- Horse Canyon Area (61)
- East Valley (8)
- Peripheral (1)
- Rocky Pass (4)
- Shoshone (12)
- Toiyabe Catchment (6)
- Cortez Canyon seeps (4)
- Mapped Cortez spring (1)
- NE Toiyabe seeps (2)
- NE Corner seeps and spring (3)
- NE Survey Area seep (1)

Source: Geomega 2006e.
Note: Numbers reflect site identification numbers.

Cortez Hills Expansion Project

Figure 3.2-3

Monitored Seeps and Springs in the HSA

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The Northeast Corner seeps and springs consist of three springs located on the northwest slopes of Mount Tenabo (Geomega 2006e). Flows of less than 1 gpm were observed at each site in March 2000. In June and August 2002, however, these sites were dry (see **Table B-1** in Appendix B).

An additional surface water feature, the former Cortez Pit lake, was located in the open pit at the Cortez Mine. Until 1999, it had a water depth of approximately 60 feet. It has since drained and not refilled (Geomega 2006e). Water quality monitoring results from the pit lake are discussed below.

Saline flats exist where streams empty into areas with no outflow. Temporary ponding occurs on saline flats after snowmelt or prolonged rainfall.

Flood Hydrology

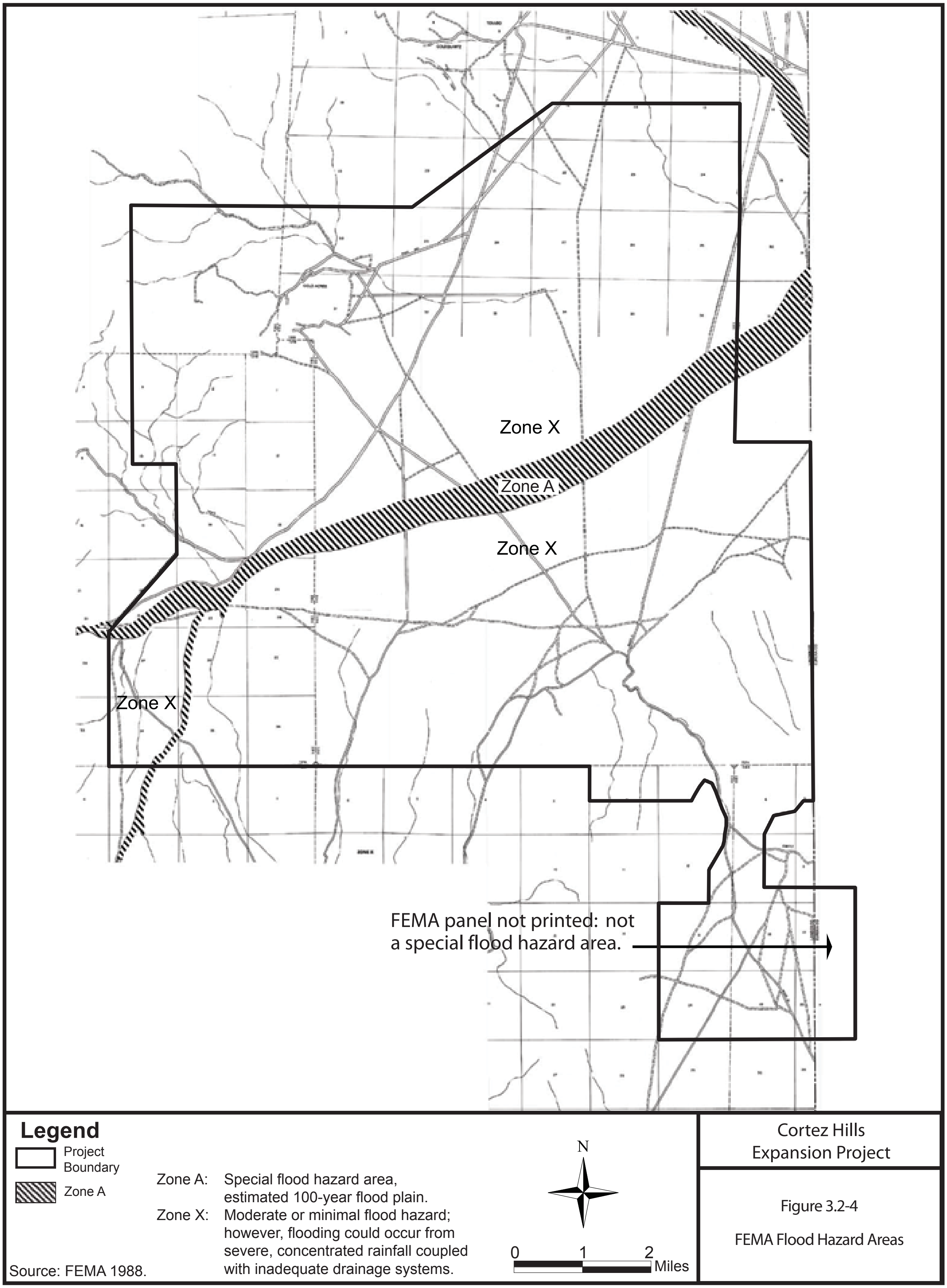
Site-specific flood peak flows and total runoff volumes for the drainages described above have not been estimated. Based on earlier EIS work in the area (BLM 2000a), 24-hour/100-year peak flows for the smaller mountain watersheds are probably less than 500 cubic feet per second (cfs), and on the order of 1,500 to 2,000 cfs for larger mountain watersheds such as Fourmile Canyon. As shown in **Figure 3.2-4**, a Special Flood Hazard Area (SFHA) Zone A delineation for the 100-year flood occurs across Crescent Valley through the central part of the project boundary (Federal Emergency Management Agency [FEMA] 1988). This delineation follows the low elevation drainage path across the valley and generally is 0.5- to 0.75-mile-wide. No other SFHAs are delineated in the study area.

Waters of the U.S.

Surveys conducted by JBR (2006a, 2002b, 2000c) delineated wetlands and waters of the U.S. within the study area. Such delineations were performed in accordance with Section 404 of the CWA as administered by the USACE. In this region of Nevada, these areas typically are found in association with larger springs and seeps or the moist bottoms of valleys and canyons. Wetlands are defined by the USACE and the U.S. Environmental Protection Agency (USEPA) in 40 CFR 230.3 and 33 CFR 328.3.

On January 9, 2001, the U.S. Supreme Court issued a decision in Solid Waste Agency of Northern Cook County (SWANCC) v. USACE, No. 99-1178. The decision invalidated part of the regulatory definition of "waters of the United States" as previously used by the USACE and the USEPA. Therefore, based on the SWANCC decision, the rationale for the USACE's jurisdictional determinations has changed. The USACE may require the presence of a defined channel/bed and bank connection to known interstate waters or to waters with a clear tie to interstate or foreign commerce before claiming jurisdiction. Many isolated wetlands, including wetlands located in basins that exhibit interior design, such as Grass Valley, are no longer subject to jurisdiction by the USACE. The USACE is continuing to evaluate its interpretation of the SWANCC decision. Recent determinations have stated that the SWANCC decision applies only to wetlands, and that isolated drainages may still represent jurisdictional features.

Due to the SWANCC decision, additional field investigations were conducted in April 2002 to identify defined channel connections between waters (including wetlands) within portions of the study area (JBR 2002b).



Cortez Hills Expansion Project

Figure 3.2-4

FEMA Flood Hazard Areas

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The field investigations for defined bed and bank connections between the area surveyed and the Humbolt River did not identify any defined channel connections. All channels in the northern portion of the study area lose definition on the alluvial fans or on the floor of Crescent Valley, and there are no perennial waterbodies within Crescent Valley (BLM 2000b). In addition, no continuous defined channels were identified from the southern Cortez Mountains or the eastern flanks of the northern Toiyabe Range to the Grass Valley playa. It was determined that Horse Creek does not share a defined bed and bank connection with Willow or Pine creeks (JBR 2002b). This was reconfirmed by the October 2006 JBR field investigation and report (JBR 2006b).

The Grass Valley Hydrologic Basin Area, in which a portion of the proposed project would be developed, is a closed basin with no outflow. Channels draining the southwestern Cortez Mountains and the eastern flank of the northern Toiyabe Range are isolated and lack a connection to interstate or foreign commerce. A large playa has formed in the bottom of the basin. The USACE jurisdictional determination was written on June 25, 2002, which concurred that no jurisdictional waters are located within the portion of the proposed project area that was surveyed by JBR in 2000 and 2002 (USACE 2002).

In 2006, JBR conducted an additional wetland and waters of the U.S. survey in the eight drainage areas within the southeastern portion of the study area including:

- Copper Canyon
- Unnamed drainage, west of the North Toiyabe Crest
- Northern drainages, east flanks of the North Toiyabe Range
- North-central drainage, east flanks of North Toiyabe Range
- Central drainage, east flanks of North Toiyabe Range
- South-central drainage, east flanks of North Toiyabe Range
- Southern drainage, east flanks of North Toiyabe Range
- Wenban Spring Road drainages, east flanks of North Toiyabe Range

The Copper Canyon drainage includes a main fork and several tributary canyons within which several seeps and springs were noted to support wetlands.

The area in which the wetland and waters of the U.S. delineations were conducted in 2006 was part of one of three survey area drainage basins evaluated by JBR in 2002. Based on the information in the 2002 waters of the U.S. report, the USACE determined that no waters of the U.S. occurred within the study area. The USACE determined that intermittent and ephemeral creeks in the study area were not connected to tributaries to the Humboldt River, a navigable water.

Surface Water Quality

Waters of the State of Nevada are defined in the Nevada Revised Statutes Chapter 445, Section 445.191 and include, but are not limited to: 1) all streams, lakes, ponds, impounding reservoirs, marshes, water courses, waterways, wells, springs, irrigation systems, and drainage systems and; 2) all bodies of accumulations of water, surface and underground, natural or artificial.

Water quality standards for state waters have been established by the State of Nevada under NAC 445A.117 through 445A.128. Standards for toxic materials applicable to designated beneficial uses of surface water are described in NAC 445A.144 and summarized in **Table 3.2-2**.

Analytical water chemistry data have been compiled from several sources to document baseline surface water quality conditions. Analytical data for surface water located within the study area exists for Mill Canyon, Fire and Indian creeks; 42 seeps/springs (JBR 2005a,b, 2004); three hot springs; and the former Cortez Pit lake. In addition, field monitoring of flow rates and water quality parameters occurs quarterly or semi-annually at 42 of the seeps and springs within the study area, with records for some of the springs extending back to 1996 (JBR 1996).

Chemical analyses were performed on samples from Mill Canyon, Fire Creek, and Indian Creek in 1992. The results indicated that Mill Canyon Creek contained elevated concentrations of aluminum (0.13 milligrams per liter [mg/L]), arsenic (0.074 mg/L), and silver (0.22 mg/L). The elevated metal concentrations likely are attributable to historic mining and milling operations in Mill Canyon (Geomega 2006d). Most other surface water samples met drinking water standards, except for aluminum, which exceeded secondary drinking water standards for aluminum in Indian Creek (0.139 mg/L).

Of the 42 seeps and springs in the study area that have been monitored for flow rates and water quality parameters, 24 were selected for quarterly monitoring and 7 were selected for semi-annual monitoring. The Toiyabe Catchment group springs are neutral to alkaline (pH 6.5 to 9), with low to moderate dissolved solids (specific conductivity of 400 to 1,520 micromhos [µmhos] per centimeter). Flows fluctuate seasonally, ranging from dry to flows of less than 1 gpm.

In the vicinity of the Cortez Hills and Pediment deposits, 11 seeps and springs in five areas (Cortez Canyon spring, Northeast Toiyabe seeps, Cortez Canyon seeps, Northeast Survey Area seep, and Northeast Corner seeps and spring) were monitored for water quality parameters and flow rates by JBR from June 2002 through 2004 (JBR 2004). Field measurements of flow rate, conductivity, pH, temperature, turbidity, and dissolved oxygen are provided in the water resources baseline report (Geomega 2006d, Appendix B); flow data are summarized in **Table B-1** in Appendix B. The four seeps in Cortez Canyon and the three Northeast Corner seeps and springs were dry in every monitoring event. The Northeast Survey Area seep had an open area of water in June 2002, and then appeared as a wet area until July 2003, when it appeared dry; subsequently, the area became wet again. The Northeast Toiyabe seeps were dry in all sampling events, except in March 2004, when flow was approximately 3 to 5 gpm. The Cortez Canyon spring had only a trickle of water during most sample events.

Analytical results of water samples taken from the former Cortez Pit lake are characteristic of waters from carbonate systems. Four samples were collected from the former lake surface and were characterized by high alkalinity (228 to 282 mg/L), pH values between 8.0 and 8.1, calcium from 43 to 45 mg/L, TDS concentrations between 425 and 438 mg/L, and low metal concentrations.

Table 3.2-2
Nevada Water Quality Standards

	Groundwater		Surface Water			
	Nevada Drinking Water Standards		Municipal or Domestic Supply	Nevada Agriculture		
Constituent (mg/L)[1]	Primary MCL[2]	Secondary MCL		Irrigation	Livestock Watering	Aquatic Life
Physical Properties						
Dissolved Oxygen	--	--	Aerobic	--	Aerobic	5.0
Color (color units)	--	15[3]	75	--	--	--
TDS (at180ºC)	--	500[4]; 1,000[3]	500[4]; 1,000[3]	--	3,000	--
Turbidity (NTU)	--	--	--	--	--	--
Inorganic Nonmetals						
Ammonia (unionized) (Total NH_3 as N)	--	--	0.5	--	--	--
Chloride	--	250[4]; 400[3]	250[4]; 400[3]	--	1,500	--
Cyanide (as CN)	0.2	--	0.2	--	--	--
Fluoride	4.0	2.0[4]	--	1.0	2.0	0.0052[5]
Nitrate (as N)	10	--	10	--	100	--
Nitrite (as N)	1.0	--	1.0	--	10	--
pH (standard units)	--	6.5-8.5[3]	5.0-9.0	4.5-9.0	6.5-9.0	6.5-9.0
Sulfate	--	250[4], 500[3]	250[4]; 500[3]	--	--	--
Metals[6]/Elements						
Aluminum	--	0.05[3]-0.2[4]	---	--	--	--
Antimony	0.146[7]	--	0.146	--	--	--
Arsenic (total)	0.05[7]	--	0.05	0.10	0.20	0.18[5,8]
Barium	2.0	--	2.0	--	--	--
Beryllium	0.004	--	--	0.10	--	--
Boron	--	--	--	0.75	5.0	--
Cadmium	0.005	--	0.005	0.01	0.05	0.0006[5,9]
Chromium (total)	0.1	--	0.1	0.10	1.0	0.015[5,9]
Copper	1.3[10]	1.0[3]	--	0.20	0.50	0.0065[5,9]
Iron	--	0.3[4]; 0.6[3]	--	5.0	--	1.0
Lead	0.015[10]	--	0.05	5.0	0.10	0.0004[5,9]
Magnesium	--	125[4]; 150[3]	--	--	--	--
Manganese	--	0.05[4]; 0.1[3]	--	0.2	--	--
Mercury	0.002	--	0.002	--	0.01	0.00012[5]
Nickel	0.1	--	0.134	0.20	--	0.087[5,9]
Selenium	0.05	--	0.05	0.02	0.05	0.005[5]
Silver	--	0.1[3]	--	--	--	0.0014[5,9]
Thallium	0.002	--	0.013	--	--	--
Zinc	--	5.0[4]	--	2.0	25	0.584[5,9]

[1] Units are milligrams per liter (mg/L) unless otherwise noted.
[2] MCL = Maximum contaminant level. Federal primary standards of July 1, 1993, are incorporated by reference in NAC 445A.453.
[3] Nevada secondary MCLs.
[4] Federal secondary MCLs.
[5] 96-hour average.
[6] The standards for metals are expressed as total recoverable unless otherwise noted.
[7] Federal primary MCL for arsenic is 0.01 mg/L; and for antimony is 0.006.
[8] Standard for arsenic (III).
[9] Standard is dependent on site-specific hardness; displayed value is based on a hardness of 60 mg/L as calcium carbonate. (See NAC 445A.144 for equations.)
[10] Value is action level for treatment technique for lead and copper.

Sources: 40 CFR 141.51; 40 CFR 143.3; NAC 445A.119, 445A.144, 445A.453, and 445A.455.

3.2.1.3 Groundwater Resources

Baseline information for describing the hydrogeologic conditions in the study area is presented in the project's Baseline Characterization Report (Geomega 2006e). The current understanding of the hydrogeologic conditions is based on: 1) previous studies of water resources in Crescent and Grass valleys (e.g., Bedinger et al. 1984; Berger 2000; Everett and Rush 1966; Thomas et al. 1986; Zones 1961); 2) lithologic logs for exploration borings, monitoring wells, and test production wells; 3) aquifer pumping test results, 4) monthly water level and quarterly water quality monitoring in monitoring wells; and 5) hydraulic properties of lithologic units within the study compiled from local- and regional-scale hydrologic investigations. Previous studies in the region have indicated a wide range of hydraulic properties of bedrock units and characterized the fault-controlled and hydraulically isolated nature of the bedrock groundwater system as summarized by Geomega (2006b, 2007f). The results of these previous studies have been combined with site-specific data to develop a conceptual understanding of the hydrogeologic groundwater conditions in the study area.

Hydrogeologic Setting

Recharge, storage, and movement of groundwater is dependent in part on the geologic conditions and the topography of a site. The general stratigraphic and structural framework of the study area is described in Section 3.1, Geology and Minerals. For the purposes of characterizing the groundwater conditions in the area, the geologic formations have been grouped into seven hydrolithologic units (Geomega 2006e). The general distribution of these units is presented in **Figure 3.1-2**, and their physical characteristics are summarized in **Table 3.2-3**. These seven hydrostratigraphic units include two distinct types of materials: fractured rock (carbonate, siliceous, intrusive, volcanic, and conglomerate bedrock), and unconsolidated to poorly consolidated sediments (alluvial and basin fill deposits). In the bedrock units, recharge, storage, flow, and discharge of groundwater primarily are controlled by the secondary features (fractures, faults, and solution cavities) that have enhanced the porosity and permeability of the rock. In the unconsolidated to poorly consolidated sediments, the groundwater is stored and transmitted through interconnected pores within the sediments.

Bedrock Units. The carbonate hydrolithologic unit (herein, referred to as the carbonate unit) correlates to the eastern assemblage Paleozoic rocks discussed in Section 3.2.1, Geology and Minerals. In summary, the carbonate unit is exposed west of the Cortez fault and east of the Cortez fault along the ridge of the Cortez Mountains. At these locations, the Paleozoic rocks were up-warped, and the upper plate (western assemblage) rocks were removed by erosion. Although the carbonate unit consists mostly of carbonate rocks (i.e., limestone and dolomite), it also contains minor amounts of other rock types (i.e., quartzite and shale). The carbonate unit in the Cortez window within the study area correlates with the carbonate unit encountered beneath the alluvium at the original Pipeline Project in the Gold Acres window. Therefore, it is reasonable to expect similar values of hydraulic properties for this same lithologic unit within the two windows. The hydrologic properties of the carbonate unit in the Gold Acres window were evaluated from available aquifer test data and operational dewatering data collected during early stages of the Pipeline Project. Aquifer test data from the Pipeline Project area indicate that the local hydraulic conductivity for the

Table 3.2-3
Hydrolithologic Units in the Study Area

Hydrolithologic Unit	Geologic Map Units[1] (Geologic Age)	Estimated Thickness (feet)	Lithology	General Hydrologic Characteristics
Alluvium	Qg, Ql, Qal, Qcd, Qb, Qco (Quaternary)	400 to 800	Alluvial fan and flood plain deposits, eolian sand, playa silt and clay, terrace gravel, colluvium, landslide deposits.	Hydraulic conductivity ranges from 0.5 to approximately 2,000 feet per day; specific yield ranges from 0.1 to 0.3.
Older Basin Fill	Qg, Qal (Quaternary and Tertiary)	0 to 9,000 ±	Older alluvial sediments. Poorly sorted to well-sorted gravel, sand, silt, and clay; interbedded with finer-grained sediments. Partially consolidated at depth.	Hydraulic conductivity ranges from approximately 0.1 to 10 feet per day; specific yield ranges from 0.1 to 0.2. Permeability generally decreases with compaction.
Tertiary Conglomerate	Tcl, Tcs (Tertiary)	0 to 1,000	Composed of an upper monolithic limestone conglomerate and a lower heterolithic siltstone conglomerate in the vicinity of the proposed Cortez Hills Pit.	Based on local pump test, hydraulic conductivity ranges from 1 to 0.1 feet per day.
Volcanic rocks	Tc, Tcv, Tcg, Tqp (Tertiary and Jurassic)	Up to 8,000 in Toiyabe Range; 3,500 to >10,000 (+/-) in Cortez Mountains.	Welded tuff, consisting of dacitic ash flows and volcanic debris with local quartz porphyry in the Toiyabe Range; volcaniclastic rock and rhyolite/rhyodacite flow in Cortez Mountains and Dry Hills. Basalt and andesite flows in Cortez Mountains and Shoshone Range.	Hydraulic conductivity ranges from 0.01 to 10 feet per day; the upper value of the range corresponds to locally fractured areas.
Intrusive rocks	Jal, Js, Jqm (Tertiary and Jurassic)	--	Predominantly granodiorite and quartz monzonite.	Hydraulic conductivity ranges from 0.001 to approximately 25 feet per day. The larger conductivity values correspond to locally fractured rock.
Siliceous rocks	Western Assemblage: Ds, Se, Ov, Ovi (Permian to Cambrian)	20,000	Quartzite, chert, siltstone, shale, sandstone, conglomerate, and argillite. Minor amounts of greenstone, dolomite, and limestone.	Hydraulic conductivity ranges from approximately 0.001 to 100 feet per day. Most values are between 0.01 and 0.5 for unfractured rock.
Carbonate rocks	Eastern Assemblage: Dp, Dw, Srm, Ohc, Oe, Ch, (Devonian to Cambrian)	>6,000 in Crescent Valley	Limestone, dolomite, siltstone, claystone, chert, quartzite, and shale.	Hydraulic conductivity ranges from 0.1 to 150 feet per day. Most values are between 0.2 and 10 feet per day. Permeability is mostly secondary due to fracturing and solution widening.

[1] See **Figure 3.1-4** and Section 3.1, Geology and Minerals, for description of geologic units.

Source: Modified from Geomega 2006e.

carbonate unit ranges between 25 and 350 feet per day. These relatively high values are interpreted to result from localized secondary permeability associated with extensive fracturing along fault zones (Geomega 2006e).

The carbonate aquifer is a regionally extensive hydrolithologic unit in large portions of eastern and central Nevada. Aquifer test results throughout the region indicate that the carbonate aquifer has a wide range of hydraulic conductivity. For example, in the Carlin Trend area, just north of Crescent Valley, the hydraulic conductivity and storage coefficient of the carbonate aquifer unit are estimated to range from 0.1 to 150 feet per day and 0.00002 to 0.014, respectively (Maurer et al. 1996). At the Nevada Test Site, the carbonate aquifer has an estimated hydraulic conductivity that ranges from 0.7 to 700 feet per day (Winograd and Thordarson 1975). Harrill and Prudic (1998) and Plume (1996) reported values of hydraulic conductivity for eastern Nevada that range from 0.005 to 900 feet per day.

The siliceous hydrolithologic unit consists of the entire package of rocks included within the western assemblage as described in Section 3.1, Geology and Minerals. This hydrolithologic unit is composed of chert, argillite, shale, siltstone, sandstone, conglomerate, and quartzite, with minor amounts of carbonate rocks. Within the study area, siliceous rocks are exposed in the north Toiyabe Range immediately west of the Cortez window, and in the Cortez Mountains; elsewhere, they are covered by Tertiary volcanic rocks and alluvial deposits. Except in windows where these rocks have been removed by uplift and erosion, the siliceous hydrolithologic unit generally overlies the carbonate hydrolithologic unit.

Groundwater elevations in wells completed in siliceous bedrock have been measured at several locations in the Cortez Mountains. Highly variable water levels have been recorded that range from 5,280 to 7,300 feet amsl (Geomega 2006e). In general, only the lowest values within this range are consistent with regional water table elevations (Bedinger et al. 1984; Thomas et al. 1986). The available data and other regional studies (Maurer et al. 1996; Stone et al. 1991) suggest that groundwater flow within siliceous bedrock of the mountain ranges is restricted and compartmentalized by geologic structures.

No aquifer tests have been conducted in rocks of the siliceous hydrolithologic unit within the project area since these units are not primary targets for mine dewatering. In the Carlin Trend, reported ranges of hydraulic conductivity and storage coefficient are approximately 0.001 to 100 feet per day and 0.00001 to 0.03 feet per day, respectively (Maurer et al. 1996) for similar rocks. In general, except along faults and fracture zones, the hydraulic conductivities of siliceous rocks are low and tend to act as barriers to regional groundwater flow (Plume 1996).

Rocks comprising the volcanic hydrolithologic unit consist primarily of the Caetano Tuff, which crops out over most of the Toiyabe Range, and has an estimated total thickness of approximately 8,000 feet (Gilluly and Mazursky 1965). No hydrologic data exist for rocks of the volcanic hydrolithologic unit in the study area; however, estimates of the hydraulic conductivity of volcanic rocks in Boulder Valley, just north of the Humboldt River, range from 0.01 to 10 feet per day (Maurer et al. 1996). At the Nevada Test Site, measured values of the hydraulic conductivity of volcanic rocks, consisting of lava flows and ash-flow tuffs, range from approximately 1.5 to 17 feet per day (Winograd and Thordarson 1975). Plume (1996) reported that 54 drill stem tests in volcanic rocks in the Railroad and White River Valleys in eastern Nevada produced hydraulic conductivity values that range from 0.000001 to 0.3 feet per day, with a mean value of 0.02 feet per day.

Intrusive rocks are exposed in the central and southern parts of the Cortez Mountains. Intrusive rocks in the southern Cortez Mountains primarily are composed of granodiorite and quartz monzonite (Muffler 1964). No aquifer tests have been performed on the intrusive rocks within the study area since they are not considered primary dewatering targets for the project. However, results of aquifer tests in similar granodiorite intrusions near the Post-Betze Mine in Boulder Valley, north of the proposed project, indicate that the hydraulic conductivity of intrusive rocks is approximately 3 to 5 feet per day where the rocks are highly fractured (Maurer et al. 1996). However, where fracturing is less extensive, intrusive rocks generally have very low permeability and impede the movement of groundwater (Plume 1996). Belcher et al. (2001) report horizontal hydraulic conductivities from 0.002 feet per day to 3.3 feet per day for Jurassic- to Oligocene-age granodiorite, quartz monzonite, granite, and tonalite in southern Nevada and parts of California.

The conglomerate hydrolithologic unit includes an upper limestone conglomerate and a lower siltstone conglomerate that occurs in the Pediment deposit located in the southern portion of the proposed Cortez Hill Pit. Results from aquifer pumping tests performed on the Tertiary conglomerate in the proposed Cortez Hills Pit area suggest that the hydraulic conductivity of this unit is roughly 0.1 foot per day (Geomega 2006d).

Basin Fill Deposits. Older basin fill consists of Tertiary- to Quaternary-age semi-consolidated deposits of conglomerate, sandstone, siltstone, claystone, freshwater limestone, and evaporite, with local interbeds of volcaniclastic rocks. Within the study area, these deposits underlie younger alluvium throughout the valley floor in Crescent and Grass valleys. The hydraulic conductivity of these older deposits is reported to range between 0.1 and 10 feet per day (Maurer et al. 1996; WMC 1995b).The depth of the contact between the younger alluvium and older basin fill deposits units is not well delineated except in the pit areas.

Recent basin fill deposits comprise an important aquifer in the Great Basin. Recent deposits of alluvial fans, landslides, stream flood plains, playas, and terrace deposits comprise the younger alluvium hydrolithologic unit. In the proposed Cortez Hills Expansion Project area, the water table is located within the bedrock, and the alluvium is unsaturated. However, groundwater occurs within the younger alluvium in Crescent and Grass valleys (Geomega 2006e). Based on the results of regional studies, the hydraulic conductivity of recent alluvial deposits is estimated to range from 0.5 to approximately 2,000 feet per day, with many values between 3 and 74 feet per day. Specific yield of recent alluvial deposits ranges from approximately 6 percent for fine-grained deposits to nearly 30 percent for coarse-grained deposits (Geomega 2006e).

Hydrostructural Units. Groundwater flow pathways are influenced by major faults that offset and displace rock units and older alluvial deposits. Depending on the physical properties of the rocks involved, faulting may create either barriers or conduits for groundwater flow. For example, faulting of softer, less competent rocks typically forms zones of crushed and pulverized rock material that behave as a barrier to groundwater movement. Faulting of hard, competent rocks often creates conduits along the fault trace, resulting in zones of higher groundwater flow and storage capacity along the fault zone compared to the unfaulted surrounding rock.

Important structural features identified in the Cortez Hills area are presented in **Figure 3.1-5**. Major hydrostructural features identified in the vicinity of the Cortez window are the Cortez fault, Crescent fault, and Cortez Hills 287 faults (**Figure 3.1-5**). The Cortez fault is a normal fault that dips steeply towards the west and forms the eastern boundary of the Cortez window. The Crescent fault also is a normal fault and major basin and range structure that marks the western boundary of the Cortez window. Variations in groundwater elevations on either side of the Cortez and Crescent faults suggest that both faults restrict the movement of groundwater across the faults and essentially compartmentalize the groundwater flow system within the Cortez window (Geomega 2006e, 2007f). The Cortez Hills 287 fault is a west-northwest trending fault located in the southern portion of the Cortez window. Groundwater elevations drop nearly 1,000 feet from south to north across the fault zone indicating that this structure is a substantial barrier to groundwater flow. Other important structures that also appear to restrict groundwater flow include the Roberts Mountain thrust fault forming the southwest boundary of the Cortez window, and the Oblique fault that intersects both the Roberts Mountain and Cortez Hills 287 faults.

Major hydrostructural structures in the vicinity of the existing Pipeline and Gold Acres complexes include the Pipeline fault and faults that bound the Gold Acres window. The Pipeline fault zone is a northwest trending fracture zone with enhanced permeability. Faults that form the boundary of the Gold Acres window appear to restrict flow based on the contrast in groundwater elevations on either side of the faults.

Groundwater Levels

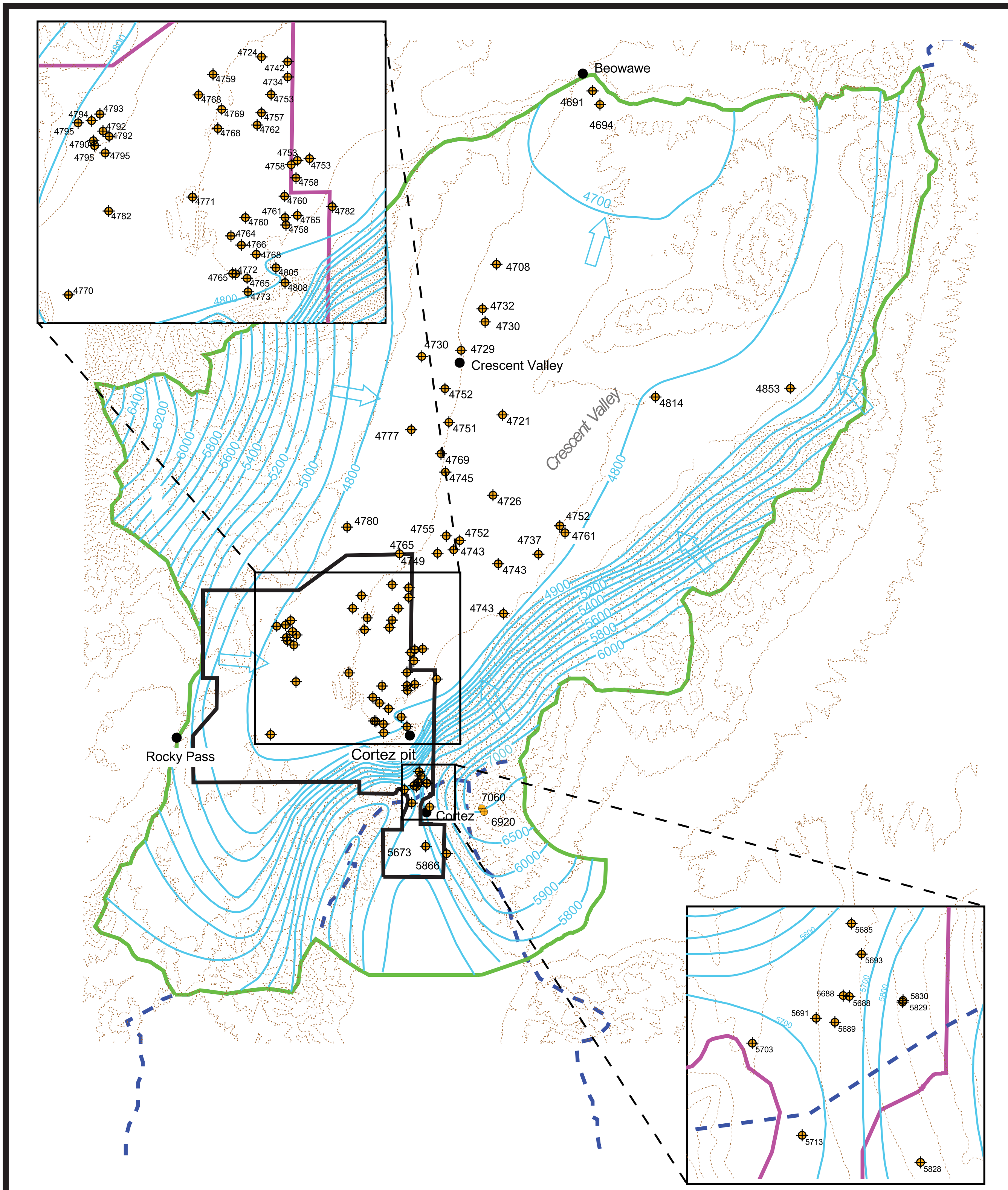
The locations of monitoring wells used to define groundwater elevations in the HSA as of December 2004 are shown in **Figures 3.2-5** and **3.2-6**. The monitoring network includes 80 wells located in Crescent Valley in the vicinity of the Pipeline Pit and infiltration basins in the vicinity of the Cortez window (Geomega 2006e), and 26 wells located in the proposed Cortez Hills Complex area. The regional flow system generally mimics the topography with steep gradients in the mountains and gentler gradients in the basins. In the Crescent Valley Hydrographic Basin, the primary flow pattern in the mountain blocks is toward the axis of Crescent Valley and toward the northeast in the basin fill sediments within the valley. The groundwater elevation contour pattern suggests that inflow to the cumulative effects study area is at Rocky Pass and outflow is to the Humboldt River in the vicinity of Beowawe. Groundwater flow in the Grass Valley Hydrographic Basin in the southern portion of the cumulative effects study area is from the mountain blocks toward the central portion of the valley with flow toward the south in the basin fill sediments.

The groundwater elevations for December 2004 as shown in **Figure 3.2-6** represent the existing or baseline conditions for this EIS. In December 2004, the water levels in the vicinity of the Pipeline Pit exhibited a depression in the groundwater surface that extended from approximately 4,800 to 4,200 feet amsl, or approximately 800 feet below the pre-mining groundwater surface. The drawdown or lowering of the groundwater levels has resulted from mine dewatering that was initiated in 1996 and continues to the present. Groundwater mounding from infiltration at the infiltration basins has resulted in an increase in water levels north, south, and to a lesser extent east of the Pipeline Pit (Geomega 2006e).

In the proposed Cortez Hills Complex area, the water level contours indicate that the groundwater surface varies by over 1,200 feet across the proposed pit area (**Figure 3.2-6**). In addition, water levels in the Cortez window indicate that there is an existing cone of depression centered approximately 1 mile northwest of the proposed Cortez Hills Pit. Water levels in the cone of depression are approximately 150 to over 250 feet lower than adjacent areas. Water levels in monitoring wells located in the vicinity of the existing Cortez Pit have experienced a relatively steady decline over the past several years (Geomega 2003b).

Aquifer Recharge and Discharge

Inflow and outflow from the groundwater system were estimated by Geomega (2006e, 2007f) to establish a baseline water balance for the HSA. The estimated average annual groundwater budget (existing conditions) is presented in **Table 3.2-4**. Existing groundwater inflow components include precipitation recharge, infiltration of excess mine water, and subsurface inflow at Rocky Pass. Groundwater outflow components include evapotranspiration from phreatophyte areas in Crescent Valley; groundwater withdrawal associated with the existing mine dewatering operations; discharge at springs; and underflow to the Humboldt River, Grass Valley, and Pine Valley.



Legend

- Project Boundary
- Well with Observed Water Elevation
- HSA
- Hydrographic Basin Boundary
- Ground Elevation Contours: 400-foot Intervals
- Estimated Water Elevation Contours: 100-foot Intervals (unless noted)
- Direction of Groundwater Flow

Source: Geomega 2006e.

N

0 5 10 Miles

Cortez Hills Expansion Project

Figure 3.2-5
Regional Groundwater Elevations Prior to Pipeline Mine Dewatering

06/20/07

Table 3.2-4
2004 Estimated Annual Groundwater Budget for the HSA[1]

Budget Component	Crescent Valley and Grass Valley Groundwater System (acre-feet per year)
Groundwater Inflow	
Precipitation Recharge	22,800
Infiltration Recharge	34,700
Groundwater Inflow (Rocky Pass)	300
Total Inflow	57,800
Groundwater Outflow	
Evapotranspiration	16,300
Groundwater Pumpage	37,600
Consumptive Uses	2,900
Discharge to Grass Valley	1,300
Discharge to Pine Valley	400
Net Groundwater Discharge to Humboldt River	400
Total Outflow	58,900

[1] Estimation based on results from the calibrated numerical model.

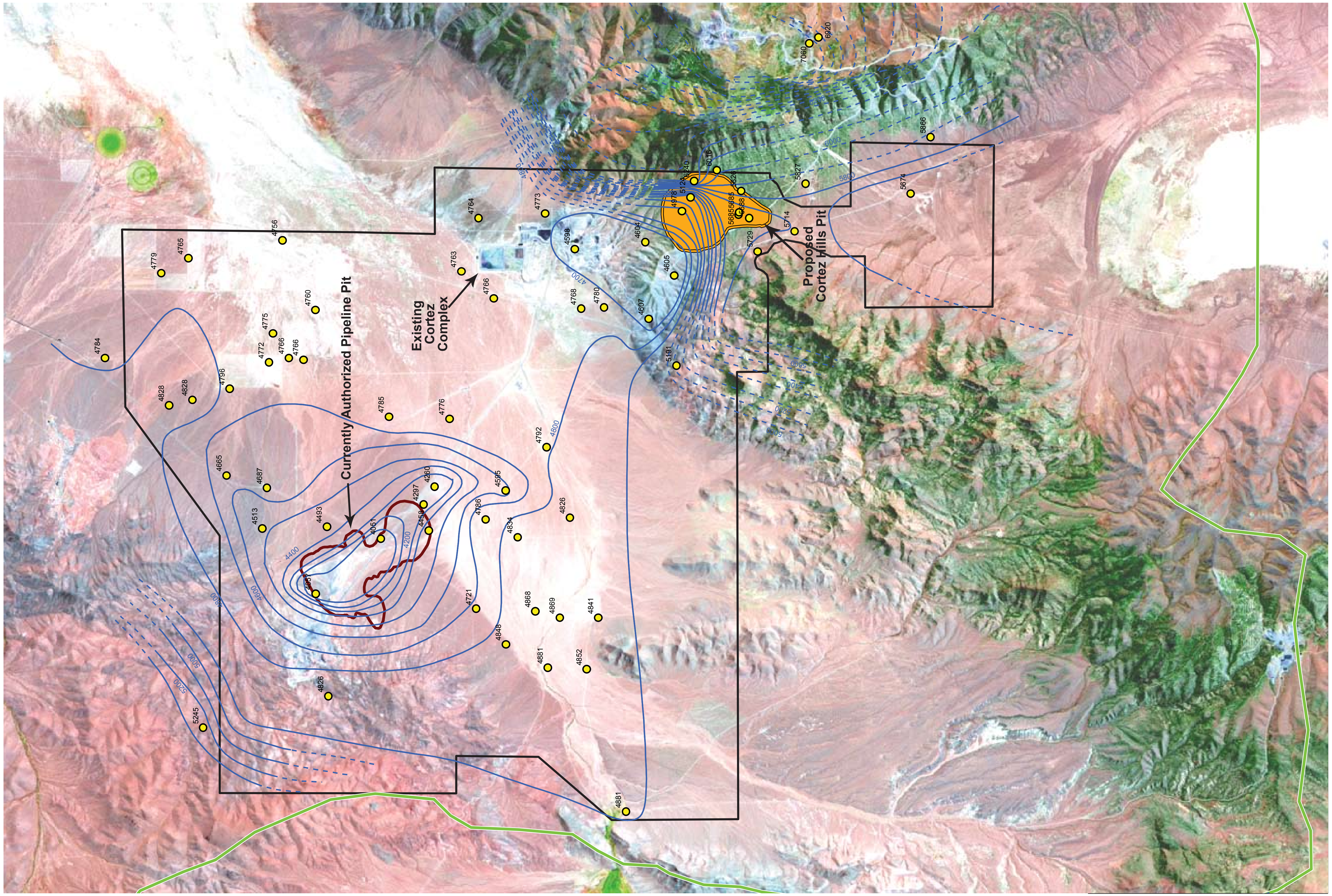
Source: Geomega 2006e, 2007f.

The largest natural contribution to groundwater recharge comes from precipitation infiltration in the higher elevations. Smaller amounts of recharge come from infiltration in artificial infiltration basins and groundwater underflow at Rocky Pass into Crescent Valley. Evapotranspiration is the primary natural mechanism of groundwater loss from the HSA. Other sources of groundwater outflow include underflow from the northern part of Grass Valley to the central part of Grass Valley across the HSA boundary, underflow from the Horse Canyon area to the central part of Pine Valley across the HSA boundary, discharge from seeps and springs, and outflow to the Humboldt River.

The primary sources of aquifer recharge are precipitation and stream runoff from snowmelt. As is typical in Nevada, the higher elevations generally receive more rain and snow. This increase in precipitation at higher elevations recharges the bedrock aquifers and local perched systems through fractures in the bedrock outcrops or where bedrock is a porous sedimentary or volcanic unit. Where streams emerge from the mountains, a percentage of the stream flow is lost as water infiltrates and recharges the alluvium.

Recharge to the groundwater system from direct precipitation was estimated using an empirically derived relationship between precipitation, recharge, and altitude similar to that developed by Maxey and Eakin (1949). The revised Maxey-Eakin relation developed by Nichols (2000) is based on a distribution of average annual precipitation into zones where each zone is related to groundwater recharge via empirically derived recharge coefficients. The methodology used to estimate recharge is described in the project Baseline Characterization Report (Geomega 2006e). On the basis of the revised Maxey-Eakin method, and accounting for the spatial distribution of recharge to these three landforms, the total recharge to the HSA is estimated to be approximately 22,800 acre-feet per year (**Table 3.2-4**).

CGM's current water management operations in Crescent Valley include a system to reinfiltrate excess water produced from dewatering operations. Excess mine dewatering water is discharged to surface



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0 1 2 Miles

Legend

Project Boundary

Well with Observed Water Elevation

Groundwater Elevations

HSA

Source: Geomega 2006e.
Note: Groundwater elevations based on December 2004 data.

Cortez Hills Expansion Project

Figure 3.2-6

Project Area
Groundwater Elevations
(December 2004)

06/19/07

infiltration ponds located in six areas in southern Crescent Valley. Dewatering discharge to the infiltration system was initiated in 1996 and continues to the present. The average weekly infiltration rate between August 1996 and December 2004 was 16,200 gpm (26,100 acre-feet per year) (Geomega 2006e).

Another source of inflow to the groundwater system is surface and subsurface flows that enter Crescent Valley from the adjacent hydrographic basin in Carico Lake Valley and at Rocky Pass. The combination of underflow and surface infiltration at Rocky Pass is estimated to be between 100 and 400 acre-feet per year (Geomega 2006e).

Evapotranspiration is the primary mechanism of groundwater loss from the HSA. Evapotranspiration of groundwater occurs in areas where the water table is shallow, including areas near seep and spring locations and at the valley floor of Crescent Valley. Other sources of groundwater outflow include underflow from the northern part of Grass Valley to the central part of Grass Valley across the HSA boundary, underflow from the Horse Canyon area to the central part of Pine Valley across the HSA boundary, discharge from seeps and springs, and outflow to the Humboldt River.

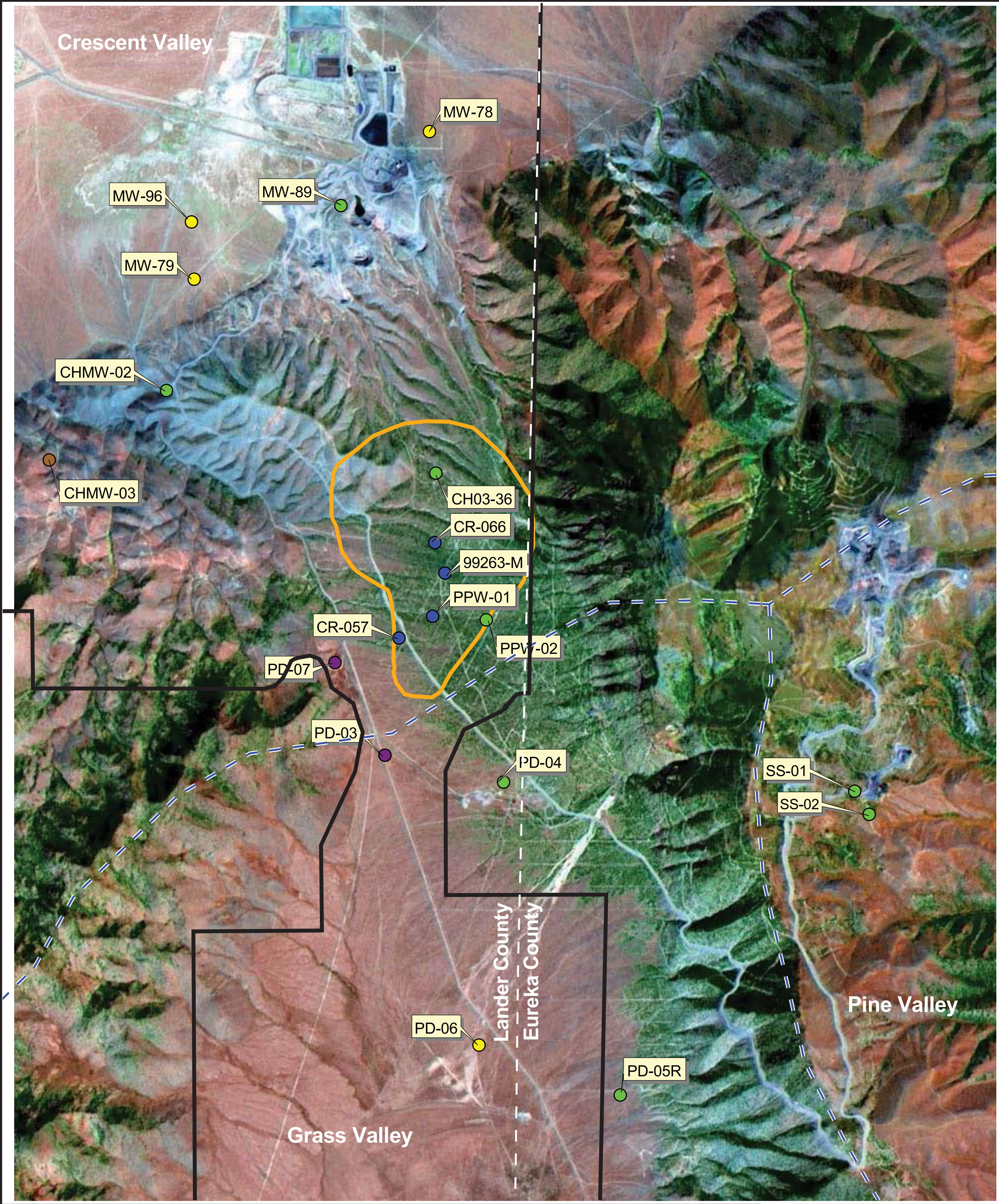
Groundwater Quality

Baseline groundwater quality data for the area was used to characterize groundwater conditions in the vicinity of the proposed Cortez Hills Complex and existing Cortez and Pipeline complexes (Geomega 2006e). Groundwater samples were analyzed for most of the standard water quality indicators including pH, alkalinity, major anions and cations, and metals for which drinking water standards exist.

Cortez and Cortez Hills Complexes. Water quality for the groundwater systems in the vicinity of the Cortez and Cortez Hills complexes has been characterized using analytical results from 17 monitoring wells distributed throughout the area. As shown in **Figure 3.2-7**, from north to south, these include three wells located in basin fill deposits in Crescent Valley approximately 1 mile west (MW-79, MW-96) or directly east (MW-78) of the historic Cortez Mine area, one well located in bedrock in the Cortez Mine area (MW-89), two wells located in bedrock northwest of the proposed Cortez Hills Complex (CHMW-02, CHMW-03), nine wells located in bedrock the vicinity of the proposed Cortez Hills Pit (CH03-36, CR-066, 99263-M, PPW-01, PPW-02, CR-057, PD-07, PD-03, and PD-04), and two wells located in northern Grass Valley (PD-06 completed in the basin fill and PD-05R completed in bedrock).

Groundwater samples from the area of the Cortez and Cortez Hills complexes generally are sodium-calcium-bicarbonate waters. There are no clear major-element distinctions between bedrock and alluvial well samples. Well MW-78, a Crescent Valley alluvial well, had relatively high proportions of sulfate compared to the other wells. Bedrock wells 99263-M and CR-066 had relatively high proportions of chloride compared to the other wells.

As summarized in **Table 3.2-5**, samples from the alluvial well in Grass Valley have moderate pH and TDS values. The Grass Valley alluvial well had iron and manganese concentrations that exceeded the Nevada secondary maximum contaminant levels (MCLs). The Crescent Valley alluvial well samples have moderate pH and slightly higher TDS, with maximum values for aluminum and manganese that exceed the Nevada



Legend

- Project Boundary
- Hydrographic Basin Boundary
- Proposed Cortez Hills Pit

Lithology at Well Completion Level

- Basin-fill Deposits
- Carbonate (lower plate) Rocks
- Intrusive Rocks
- Siliceous (upper plate) Rocks
- Tertiary Conglomerate
- Volcanic Rocks

N

0 0.5 1 Miles

Source: Geomega 2006e.

Cortez Hills Expansion Project

Figure 3.2-7
Groundwater Sampling Locations - Cortez/Cortez Hills Area

06/19/07

Table 3.2-5
Cortez/Cortez Hills Area Background Groundwater Quality

Constituent (mg/L)[1]	Applicable Nevada Drinking Water Standards[2]	Grass Valley Alluvial Well		Crescent Valley Alluvial Wells		Bedrock Wells	
		Range	Average	Range	Average	Range	Average
Aluminum	0.05[3]-0.2[4]	0.010 – 0.052	0.015	0.010 – 0.340	0.034	0.010 – 0.560	0.027
Antimony	0.146[5]	0.001 – 0.005	0.002	0.001 – 0.008	0.004	0.001 – 0.012	0.003
Arsenic (total)	0.05[5]	0.005 – 0.012	0.006	0.003 – 0.051	0.031	0.001 – 0.130	0.019
Barium	2.0	0.047 – 0.063	0.056	0.010 – 0.100	0.052	0.003 – 0.291	0.086
Beryllium	0.004	0.001 – 0.002	0.001	0.001 – 0.003	0.001	0.001 – 0.002	0.001
Bicarbonate		115 – 124	119	0 – 228	159	0.305 – 164	89.3
Cadmium	0.005	0.001 – 0.002	0.001	0.001 – 0.005	0.002	0.001 – 0.002	0.001
Calcium		45 – 51	48	43 – 67	53	3.89 – 59.8	33.7
Chloride	250[3]; 400[4]	9.7 – 10.7	10.1	20.0 – 67.0	27.5	8.76 – 77.6	29.5
Chromium (total)	0.1	0.003 – 0.006	0.003	0.001 – 0.100	0.007	0.003 – 0.014	0.004
Copper	1.3[6]; 1.0[4]	0.002 – 0.003	0.002	0.001 – 0.010	0.004	0.001 – 0.081	0.004
Cyanide (as CN)	0.2	0.005 – 0.010[8]	0.005[8]	0.003 – 7.700	0.106	0.003 – 0.030	0.006
Fluoride	2.0[3];4.0[4]	0.100 – 0.200	0.153	0.100 – 2.300	1.252	0.050 – 5.980	0.480
Iron	0.3[3]; 0.6[4]	0.96 – 4.56	2.01	0.01 – 0.27	0.03	0.010 – 16.7	2.358
Lead	0.015[6]	0.003 – 0.005	0.003	0.001 – 0.020	0.004	0.001 – 0.008	0.003
Magnesium	125[3]; 150[4]	26.4 –30.0	27.2	5.8 – 23.0	16.9	0.020 – 28.0	14.8
Manganese	0.05[3]; 0.1[4]	0.053 – 0.130	0.088	0.001 – 0.310	0.025	0.001 – 1.010	0.210
Mercury	0.002	0.0001 – 0.0002	0.0001	0.0001 – 0.0010	0.0004	0.0001 – 0.0003	0.0001
Nickel	0.1	0.005 – 0.010	0.005	0.001 – 0.011	0.006	0.001 – 0.012	0.005
Nitrate (as N)	10	0.010 – 0.030[9]	0.013	0.010 – 1.200[9]	0.350	0.010 – 2.080[9]	0.535
pH (standard units)	6.5-8.5[4]	7.62 – 8.08	7.77	7.14 – 8.30[7]	7.77	6.64 – 11.53[7]	8.265
Potassium		2.7 – 3.4	2.9	1.9 – 16.6	8.3	2.10 -16.0	7.439
Selenium	0.05	0.002 – 0.010	0.005	0.001 – 0.040	0.005	0.001 – 0.011	0.005
Silver	0.1[4]	0.003 – 0.005	0.003	0.001 – 0.010	0.004	0.001 – 0.005	0.003
Sodium		15.3 – 17.8	16.0	38.0 – 98.0	63.7	10.8 – 140.0	34.1
Sulfate	250[3], 500[4]	58.9 – 67.9	63.2	85.0 – 365.0	219.5	0.6 – 121.0	34.6
Thallium	0.002	0.001 – 0.002	0.001	0.001 – 0.003	0.001	0.001 – 0.002	0.001
Total Alkalinity		188 – 204	195	1 – 317	208	22 – 500	159
TDS	500[3]; 1000[4]	230 – 324	282	305 - 547	425	94.0 – 540.0	266
Zinc	5.0[4]	0.003 – 0.005	0.003	0.003 – 0.085	0.012	0.003 – 0.019	0.004

[1] Units are mg/L unless otherwise noted.
[2] Nevada primary MCLs unless otherwise noted. Federal primary standards of July 1, 1993, are incorporated by reference in NAC 445A.453.
[3] Federal secondary MCLs.
[4] Nevada secondary MCLs.
[5] Federal primary MCL for arsenic is 0.01 mg/L; federal primary MCL for antimony is 0.006 mg/L.
[6] Value is action level for treatment technique for lead and copper.
[7] Lab pH.
[8] Weak acid-dissociable cyanide.
[9] Nitrate + nitrite (as N).

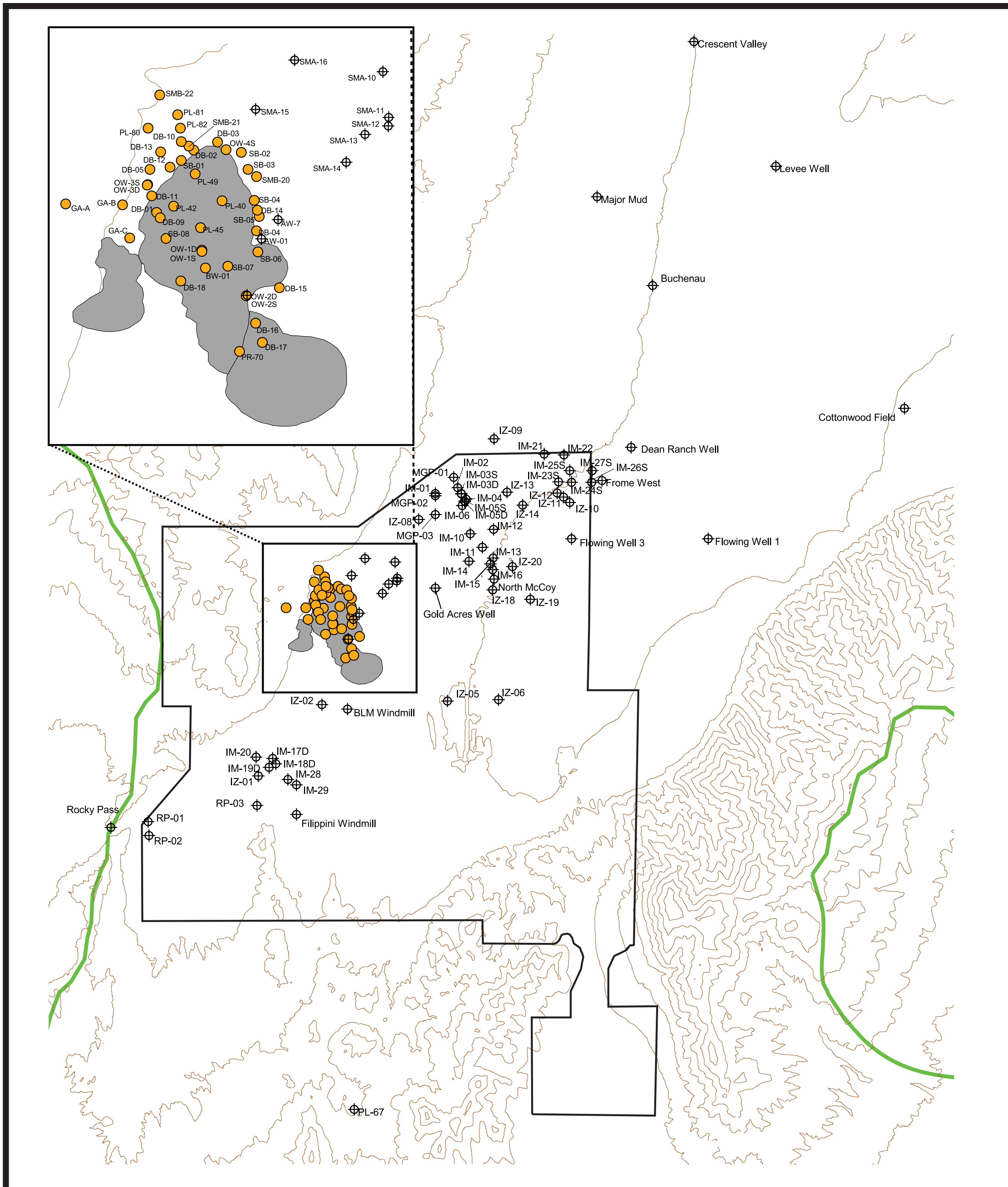
Source: 40 CFR 141.51; 40 CFR 143.3; NAC 445A.119, 445A.144, 445A.453, and 445A; Geomega 2006e.

secondary MCLs. Only a single aluminum analysis from well MW-79 exceeded the secondary MCL of 0.2 mg/L, and the average aluminum concentration for the Crescent Valley alluvial wells of 0.034 mg/L was less than the Nevada secondary MCL (Geomega 2006e). Some samples from well MW-96 had manganese concentrations that exceeded the Nevada secondary MCL of 0.1 mg/L; the other Crescent Valley alluvial wells had manganese concentrations less than the secondary MCL. The average fluoride, iron, manganese, and sulfate concentrations for the Crescent Valley alluvial wells were below their respective Nevada secondary MCLs. Maximum reported arsenic, cyanide, lead, and thallium concentrations for the Crescent Valley alluvial wells exceeded their respective Nevada MCLs. Average concentrations of these constituents were below current Nevada MCLs, although average arsenic concentrations exceeded the federal drinking water standard for arsenic of 0.01 mg/L.

Groundwater from wells completed in bedrock in the area of the proposed Cortez Hills Complex has near-neutral pH, except for monitoring wells 99263-M and CR-066, which had samples with high pH during the first several sampling quarters. These two wells were originally exploration holes that were converted to monitoring wells post-completion. The high pH water chemistry results in the initial sampling were due to ineffective well development following the introduction of concrete into the borehole for well construction. TDS in the bedrock wells exhibited a wider range than the alluvial wells, but the average TDS for the bedrock wells was moderate (266 mg/L). The maximum aluminum concentrations in the bedrock well samples exceeded MCLs, but their average concentrations were below their respective Nevada MCLs. All samples from well CR-057, which is completed in Tertiary-age conglomerate ore (Geomega 2006e), exceeded the current Nevada MCL for arsenic. All but two of the other bedrock well samples contained arsenic concentrations below the Nevada MCL. Average bedrock well arsenic concentrations exceeded the federal drinking water standard for arsenic. Only a few fluoride analyses for the bedrock wells exceeded the Nevada secondary MCL, and the average concentration of 0.480 mg/L was below the Nevada secondary MCL. Iron and manganese concentrations in some bedrock wells exceed the Nevada secondary MCLs. The highest iron and manganese concentrations were observed in samples from wells PD-03, PD-04, PD-05R, PD-07, and CHMW-03.

Pipeline Complex. Baseline water quality in the vicinity of the existing Pipeline Complex has been characterized by analyzing samples from 80 wells completed in bedrock and basin fill units near the mine as summarized by Geomega (2006e). The well locations and well type (bedrock or basin fill) are shown in **Figure 3.2-8**. Groundwater is present in both alluvial and bedrock aquifers. As summarized in **Table 3.2-6**, average alluvial groundwater quality generally meets most of the primary and secondary drinking water standards. The average alluvial aquifer constituent concentrations exceeded the Nevada secondary MCL only for TDS. The maximum constituent concentrations in the alluvial well samples exceed the Nevada MCLs for aluminum, arsenic, beryllium, cadmium, chloride, iron, fluoride, lead, magnesium, manganese, mercury, nickel, nitrate, pH, selenium, silver, sulfate, thallium, and TDS. The major-element chemistry of the alluvial well samples is dominated by calcium, sodium, and bicarbonate. The Cottonwood Field, MGP-02, and MGP-03 wells had relatively high proportions of sodium and potassium compared to the other wells, and the Crescent Valley and the Rocky Pass wells have substantial proportions of chloride and sulfate ions.

Bedrock groundwater in the Pipeline Complex area has lower average TDS and major element concentrations than alluvial groundwater. However, average metals concentrations tend to be higher in the bedrock well samples than the alluvial well samples. The average bedrock aquifer results exceed Nevada



Legend

- Project Boundary
- HSA
- Elevation Contours: 400-foot intervals
- Existing Pipeline Pit

Sampling Locations

- Alluvial Completion
- Bedrock Completion

Source: Geomega 2006e.

Cortez Hills
Expansion Project

Figure 3.2-8
Groundwater Sampling Locations -
Pipeline and
Crescent Valley Areas

Table 3.2-6
Background Groundwater Quality in the Vicinity of the Pipeline Complex

Constituent (mg/L)[1]	Applicable Nevada Drinking Water Standards[2]	Alluvial Wells		Bedrock Wells	
		Range	Average	Range	Average
Aluminum	0.05[3]-0.2[4]	0.005 – 1.07	0.045	0.02 – 0.47	0.053
Antimony	0.146[5]	0.001 – 0.05	0.004	0.002 – 0.05	0.007
Arsenic (total)	0.05[5]	0.002 – 0.18	0.01	0.002 – 0.235	0.021
Barium	2.0	0.005 – 0.5	0.065	0.01 – 0.5	0.082
Beryllium	0.004	0.001 – 0.01	0.002	0.002 – 0.01	0.003
Bicarbonate	--	0 – 650	248	1 – 584	281
Bismuth	--	0.05 – 0.1	0.057	0.05 – 0.05	0.05
Cadmium	0.005	0.001 – 0.01	0.003	0.002 – 0.326	0.005
Calcium	--	1.6 – 1,600	128	22.4 - 140	60.2
Chloride	250[3], 400[4]	4 – 4,270	152	4 – 289	30.1
Chromium (total)	0.1	0.002 – 0.06	0.009	0.002 – 0.051	0.009
Cobalt	--	0.005 – 0.05	0.012	0.007 – 0.012	0.009
Copper	1.3[7], 1.0[4]	0.002 – 0.13	0.011	0.002 – 73.4	0.334
Cyanide (as CN)	0.2	0.005 – 0.02[8]	0.009	0.005 – 0.08	0.01
Fluoride	2.0[3];4.0[4]	0.1 – 20	1.631	2.1 – 3.8	3.03
Iron	0.3[3]; 0.6[4]	0.008 – 16.8	0.166	0.008 – 159	0.813
Lead	0.015[6]	0.002 – 0.05	0.007	0.002 – 0.062	0.007
Magnesium	125[3]; 150[4]	0.098 - 592	42.8	1.7 – 55.1	23.4
Manganese	0.05[3]; 0.1[4]	0 – 2.72	0.048	0.002 – 2.32	0.052
Mercury	0.002	0.0001 – 0.5	0.002	0.0002 – 0.0052	0.001
Nickel	0.1	0.002 – 0.29	0.016	0.002 – 0.044	0.015
Nitrate (as N)	10	0.02 – 65[9]	3.675[9]	0.01 – 4.2[9]	0.416[9]
pH (standard units)	6.5-8.5[4]	6.79 – 11.7[7]	7.68	7.01 – 8.5[7]	7.68
Potassium	--	1.1 – 88.3	15.7	2.2 – 24.6	16.3
Selenium	0.05	0.002 – 0.13	0.007	0.002 – 0.014	0.004
Silver	0.1[4]	0.002 – 2.51	0.012	0.002 – 0.048	0.008
Sodium	--	29 – 2,400	159	9 – 296	95.6
Sulfate	250[3], 500[4]	82 – 4,900	442	100 – 200	126
Thallium	0.002	0.001 – 0.02	0.001	0.001 – 0.002	0.001
Total Alkalinity	--	1 – 650	237	1 – 584	277
TDS	500[3], 1000[4]	172 – 11,400	1,110	434 – 1,640	563
Zinc	5.0[4]	0.002 – 1.13	0.027	0.005 – 35.1	0.18

1 Units are mg/L unless otherwise noted.
2 Nevada primary MCLs unless otherwise noted. Federal primary standards of July 1, 1993, are incorporated by reference in NAC 445A.453.
3 Federal secondary MCLs.
4 Nevada secondary MCLs
5 Federal primary MCL for arsenic is 0.01 mg/L; federal primary MCL for antimony is 0.006 mg/L.
6 Value is action level for treatment technique for lead and copper
7 Lab pH
8 Weak acid-dissociable cyanide.
9 Nitrate + nitrite (as N).

Sources: 40 CFR 141.51; 40 CFR 143.3; NAC 445A.119, 445A.144, 445A.453, and 445A.455; Geomega 2006e.

drinking water standards for iron (secondary). Constituents with maximum values that exceed the Nevada MCLs include TDS, aluminum (secondary), arsenic, beryllium, cadmium, copper (secondary), iron (secondary), lead, manganese (secondary), mercury, and zinc (secondary). The major-element chemistry of the bedrock well samples is mostly dominated by calcium, sodium, and bicarbonate. However, the chemistry of water from well OW-3S is dominated by calcium, sodium, chloride, and sulfate. Samples from wells SMA-16, SMB-22, and PL-80 had higher calcium plus magnesium and lower sodium plus potassium proportions than the other bedrock wells; SMA-16 and SMB-22 samples also contained relatively high proportions of sulfate.

Infiltration Basins Areas. The existing infiltration basins are used to discharge excess water from the currently authorized Pipeline Pit dewatering system to the alluvial aquifer system. The chemistries of produced and background alluvial water prior to infiltration are compared in **Table 3.2-7**. Solute concentrations in the produced water are lower than the Nevada MCLs except for aluminum, which exceeds the secondary standard. Produced water arsenic concentrations are below the Nevada MCL of 0.05 mg/L but above the federal MCL of 0.01 mg/L. Transient changes in groundwater quality have been observed in monitoring wells adjacent to the infiltration sites. These changes are caused by leaching of solutes from the vadose zone as infiltrating water percolates to the water table. The effects of leaching soluble minerals from the vadose zone on groundwater quality have been evaluated by monitoring well data for the infiltration sites as well as column tests on alluvial samples collected from the infiltration sites prior to development (Geomega 2006e). (Note: changes in water quality caused by leaching of solute minerals originally were evaluated prior to initiation of infiltration activities [BLM 1998c]).

At the Highway Infiltration site, transitory changes in water quality have been observed in all monitoring wells except IM-01, a relatively deep monitoring well located upgradient of the infiltration basins. Peak TDS, sulfate, and nitrate concentrations in a number of wells in the vicinity of the Highway Infiltration site exceeded Nevada MCLs but then declined to concentrations below their respective Nevada MCLs. Similar transient changes in groundwater chemistry were observed at the North Highway and South Highway Infiltration sites.

Downgradient monitoring of the Highway Infiltration site is provided by wells IM-3D, IM-5D, and IM-10; no degradation of groundwater quality has been noted in these wells (NDEP 2004).

Water quality changes were observed in monitoring wells adjacent to the former Filippini Infiltration site. Increases in TDS, sulfate, chloride, fluoride, magnesium, nitrate, nickel, and boron concentrations exceeded the MCLs. The relatively large changes in water quality were attributed to the fine-grained nature of sediments in this area combined with a relatively shallow water table (Geomega 2006e). These factors combined to increase evaporation from the water table, enhancing the availability of evaporate solutes.

Operation of the Filippini basins ceased in January 1998, and concentrations began to decline during 1999 to 2000. Operations at the Filippini site had the most substantial effects on groundwater concentrations in wells IM-13, IM-14, IM-15, and IM-16. Wells were installed in January 2000 and December 2002 to monitor for any potential downgradient migration of chemical constituents of concern; no downgradient migration has been observed to date (NDEP 2004).

Table 3.2-7
Currently Produced and Background Alluvial Water Chemistries Prior to Infiltration

Constituent (mg/L)[1]	Background	Produced
Aluminum	0.005	0.37
Antimony	0.006	0.005
Arsenic (total)	0.01	0.018
Barium	0.053	0.085
Beryllium	0.004	0.002
Bicarbonate	222	272
Cadmium	0.005	0.003
Calcium	58	59
Chloride	37	21
Chromium (total)	0.01	0.007
Copper	0.01	0.007
Fluoride	1.32	2.9
Iron	0.15	0.11
Lead	0.01	0.006
Magnesium	18	23.3
Manganese	0.08	0.018
Mercury	0.001	0.001
Nickel	0.04	0.009
Nitrate	0.1	0.319
pH (lab, standard units)	7.7	7.5
Potassium	11	16.3
Selenium	0.005	0.004
Silver	0.01	0.006
Sodium	77	89
Sulfate	107	133
Thallium	0.002	0.001
Total Dissolved Solids	462	533
WAD Cyanide	0.005	0.012
Zinc	0.03	0.028

[1] Units are mg/L unless otherwise noted.

Source: Geomega 2006e.

Monitoring wells were installed in the vicinity of the Rocky Pass Infiltration site. Increasing TDS and nitrate concentrations in well IM-18S have been attributed to a casing failure (NDEP 2005). Transient increases in TDS and other constituents did not exceed MCLs except for TDS in IM-19S (Geomega 2006e). Higher peak concentrations were observed in water quality around the Rocky Pass #2 infiltration site. TDS and nitrate concentrations exceeded Nevada MCLs in wells IM-49, IM-50D, IM-51D, IM-51S, IM-55D, and IM-55S. In the most recent data examined, (samples obtained during 2004) only wells IM-50D, IM-51D, and IM-51S had TDS and nitrate concentrations in excess of Nevada MCLs (Geomega 2006e). Transient concentrations of sulfate, chloride, and nickel also exceeded MCLs (Geomega 2006e). A single uncorroborated arsenic concentration of 0.07 mg/L was observed in a sample from well IM-56D, which slightly exceeded the Nevada MCL of 0.05 mg/L. These data represent water from within the infiltration mound, and do not reflect potential constituent migration downgradient of the mound (NDEP 2004).

Degradation of groundwater quality was observed in monitoring wells around the Frome Infiltration site. Transient changes were observed in TDS, sulfate, chloride, fluoride, nitrate, manganese, and boron (Geomega 2006e). Although concentrations decreased toward background, TDS remains elevated in some wells (NDEP 2004). Of the 21 basins at this site, 16 have been closed, and the remaining five basins are inactive (NDEP 2004).

Transient increases in TDS, chloride, nitrate, manganese, and boron that exceeded Nevada MCLs have been observed at the Windmill Infiltration site (Geomega 2006e). In the most recent reported groundwater analyses for TDS and nitrate from this area (obtained in 2004), only wells IM-28, IM-29, and IM-30D had concentrations greater than their respective MCLs (Geomega 2006e). Because these wells are completed in the area of mounded groundwater, elevated constituent concentrations in these samples do not indicate whether constituents are migrating downgradient from the infiltration site (NDEP 2004).

Column leaching tests were carried out using representative core samples from the infiltration sites, as described by Geomega (2006e). The results of these tests and geochemical modeling of the results indicated that the infiltrating water initially would precipitate calcite and dissolve solid phases such as gypsum, halite, and magnesite that were present in the vadose zone as a result of natural evaporation. As a result, the changes in the infiltration water chemistry would include transitory decreases in pH and alkalinity with an increase in calcium, chloride, magnesium, sodium, and sulfate concentrations. These changes in water chemistry are consistent with changes observed in the monitoring wells at the infiltration sites. Metals concentrations did not vary substantially in the column leach tests or in the monitoring well samples because of the generally low metals concentration in the alluvial sediments and dewatering water. The column test and monitoring well data together indicate that water quality tends to return to near-background conditions after the passage of approximately 13 pore volumes of infiltration water (Geomega 2006e). Geomega (2006e) provided graphs of TDS and nitrate data for Crescent Valley fence monitoring wells. None of the data exceeded their respective MCLs, although a slight upward trend approaching the MCL appeared to be present in the nitrate data from well FMW-07S.

Cortez Pit Lake. The results of five water sample analyses from the former Cortez Pit lake are presented in **Table 3.2-8**. Descriptions of the pit lake chemistry are presented in the pit lake chemistry report prepared for the project (Geomega 2007a). In summary, the pit lake water had relatively high bicarbonate alkalinity, with moderate pH (8.02 – 8.41), TDS values between 425 and 525 mg/L, and low metals concentrations. Comparison of the pit lake water chemistry with background groundwater chemistry indicated that the area groundwater and pit lake water chemistries were similar.

3.2.1.4 Waste Rock Characterization

Exposure of rocks to air and water during and after mining can cause increased weathering reactions. These weathering reactions could result in the mobilization of constituents from the exposed rocks, potentially affecting surface and groundwater resources. A key concern related to mine waste rock is the potential for acid generation through oxidation of sulfide minerals such as pyrite. Acid generated by sulfide mineral oxidation and associated metals releases from waste rock can, in some cases, affect water quality.

Table 3.2-8
Former Cortez Pit Lake Analytical Water Chemistry Data

Constituent (mg/L)[1]	Applicable Nevada Drinking Water Standards[2]	East End 6/15/1992	Middle 6/15/1992	West End 6/15/1992	6/30/1993	10/9/1996
Aluminum	0.05[3] – 0.2[4]	--	--	--	< 0.02	0.016
Antimony	0.146[5]	--	--	--	--	0.006
Arsenic (total)	0.05[5]	0.038	0.037	0.04	0.0383	0.034
Barium	2.0	0.061	0.06	0.06	0.0603	0.062
Beryllium	0.004	--	--	--	--	--
Bicarbonate	--	225	228	225	282.3	--
Cadmium	0.005	< 0.007	< 0.007	< 0.007	--	< 0.001
Calcium	--	44.2	43.1	43.1	45.4	42
Chloride	250[3], 400[4]	24.8	27.9	26.9	24.2	24
Chromium (total)	0.1	< 0.010	< 0.010	< 0.010	--	0.015
Copper	1.3[6], 1.0[4]	< 0.007	< 0.007	< 0.007	--	--
Cyanide (WAD)	0.2	< 0.005	< 0.005	< 0.005	--	--
Fluoride	2.0[3], 4.0[4]	1.78	1.76	1.76	2.4	1.42
Iron	0.3[3], 0.6[4]	0.145	0.257	< 0.050	0.134	< 0.01
Lead	0.015[6]	< 0.005	0.006	0.007	0.0043	0.002
Magnesium	125[3], 150[4]	18	17.7	17.7	18.1	17
Manganese	0.05[3], 0.1[4]	0.005	< 0.003	< 0.003	0.0017	< 0.005
Mercury	0.002	< 0.0005	< 0.0005	0.00138	0.00046	< 0.0002
Nickel	0.1	--	--	--	--	0.006
Nitrate (as N)	10	< 1.0	< 1.0	< 1.0	0.207	< 0.05
pH (standard units)	6.5 – 8.5[4]	8.02	8.07	8.13	8.07	8.41
Potassium	--	11.3	11.4	11.1	11.7	9
Selenium	0.05	< 0.005	< 0.005	< 0.005	--	< 0.001
Silica	--	--	--	--	34.43	--
Silver	0.1[4]	--	--	--	--	< 0.0005
Sodium	--	72.8	72.4	71.4	68.63	64
Sulfate	250[3], 500[4]	86.5	85.6	81.9	90.2	91
Thallium	0.002	--	--	--	--	< 0.001
Total Alkalinity	--	225	228	225	--	314
TDS	500[3], 1000[4]	434	438	425	432.3	525
Zinc	5.0[4]	< 0.005	< 0.005	0.006	0.002	0.002

[1] Units are mg/L unless otherwise noted.
[2] Nevada primary MCLs unless otherwise noted. Federal primary standards of July 1, 1993, are incorporated by reference in NAC 445A.453.
[3] Federal secondary MCLs.
[4] Nevada secondary MCLs
[5] Federal primary MCL for arsenic is 0.01 mg/L; federal primary MCL for antimony is 0.006 mg/L.
[6] Value is action level for treatment technique for lead and copper

Sources: 40 CFR 141.51; 40 CFR 143.3; Geomega 2006e, 2007a; NAC 445A.119, 445A.144, 445A.453, and 445A.455.

Characterization of waste rock at the site was described by Geomega (2007c). Waste rock was characterized by determining its acid generation potential using acid-base accounting (ABA) analyses and geochemical composition through whole-rock chemical analyses. Acid-base accounting measurements indicate whether waste rock is a likely net producer or consumer of acid that is generated by sulfide oxidation. Whole-rock chemical analyses measure the concentrations of constituents in the rocks and indicate potential sources of constituents of concern. Leachate from the waste rock was characterized by performing kinetic tests that included humidity cell testing, column tests, and field oxidation tests. These leachate characterization results were used to establish the expected variations in leachate chemistry over time.

Previous studies conducted for permitting of the existing Pipeline/South Pipeline Project provide extensive characterization testing data for waste rock from this area. These results were examined to determine whether waste rock from the proposed North Gap Pit expansion area substantially would differ from the waste rock in the currently permitted Pipeline Pit. The major rock types evaluated in the Pipeline/South Pipeline Project area were alluvium, calcareous siltstone, skarn, and marble. These rock types comprise 17, 63, 3, and 17 percent, respectively, of the waste rock in the proposed North Gap Pit expansion area. Other identified rock types were geochemically similar to the calcareous siltstone and made up approximately 1 percent of the total waste rock. As a result, these rock types were grouped with the calcareous siltstone for the purpose of waste rock characterization.

Wenban and Roberts Mountain limestones from the Cortez Hills deposit and Pediment deposit limestone conglomerate would be the predominant waste rock types in the area of the proposed Cortez Hills Pit and underground workings, comprising 89 percent of the waste rock. The alluvium rock types associated with the Cortez Hills and Pediment deposits are composed of the material between the ground surface and the bedrock in the area of the deposit, and would account for less than 6 percent of the Cortez Hills area waste rock. The Cortez Hills and Pediment deposit marble would account for less than 1 percent of the waste rock; other identified waste rock types included intrusive siliceous dikes (approximately 1 percent) and sulfide-bearing refractory material (less than 1 percent). Waste rock that would be produced by proposed mining in the Cortez Pit would be composed of 87 percent limestone. The balance of the waste rock from the Cortez Pit would be made up of dike material (5 percent) and marble (8 percent).

Representative samples of the major rock types and formations that would be mined were collected from exploration drill holes and exposures throughout the Pipeline and Cortez Hills areas. The samples were collected from a number of locations and depths to ensure that the variation within rock types and formations was assessed. In the Pipeline area, a total of 788 ABA samples and 7,514 whole rock chemistry samples were analyzed, including 248 ABA samples and 1,466 whole rock samples from the proposed North Gap Pit expansion area. In the Cortez Hills area, 779 ABA samples were analyzed, with 622 samples obtained from within the proposed Cortez Hills Pit location and 157 samples obtained from the area of the proposed underground workings. A total of 4,072 whole rock chemistry samples also were analyzed, of which 1,536 samples came from the area surrounding the Cortez Pit, 1,373 samples came from within the proposed Cortez Hills Pit footprint, and 1,163 samples were obtained from the area of the proposed underground workings (Geomega 2007c).

After ABA and geochemical analyses of the samples were completed, samples were selected for kinetic testing to determine the range of concentrations for constituents of potential concern, including arsenic, antimony, mercury, and selenium.

Whole Rock Chemistry Analyses. Samples selected for whole rock chemistry analyses were sent to a Nevada-certified laboratory for NDEP Profile 1 analysis. Analytical results for samples from the proposed North Gap Pit expansion area do not differ substantially from the results for samples obtained from the existing Pipeline Pit with respect to medians, arithmetic means, and geometric means for all analytes. However, a slightly higher maximum total sulfur value (10 percent) was observed in a few North Gap Pit expansion area hornfels samples, which constitute less than 0.1 percent of the waste rock, than for the Pipeline Pit samples (3 percent). Little variation was observed in whole rock chemistry analytical results for samples from the Cortez Pit area, proposed Cortez Hills Pit area, and proposed underground workings (Geomega 2007c). Total sulfur was less than 3 percent for all samples, and the three areas had similar chemistry for aluminum, antimony, arsenic, manganese, mercury, and selenium. For the different rock types that make up most of the waste rock for the Cortez Hills area, the distribution of these analytes were similar, although maximum antimony, arsenic, and mercury concentrations were higher in the refractory, marble, and dike rock types. These three rock types would constitute only 0.3, 0.6, and 1.2 percent, respectively, of the waste rock for the Cortez Hills area. Samples selected for kinetic testing captured most of the concentration ranges observed for antimony, arsenic, manganese, mercury, and selenium.

Comparison of the whole rock chemistry data for samples from the Cortez Hills and Pipeline areas indicates that the aluminum, antimony, arsenic, iron, manganese, mercury, and selenium compositions of waste rock from these two areas are very similar. Total sulfur concentrations observed in the proposed underground mining area were similar to the concentrations observed in the existing Pipeline Pit and proposed North Gap Pit expansion area. However, lower median, arithmetic mean, and geometric mean total sulfur concentrations were observed in the proposed Cortez Hills Pit and Cortez Pit areas. Cortez Hills area samples selected for kinetic testing had distributions of constituent concentrations (aluminum, antimony, arsenic, iron, manganese, mercury, and selenium) that are representative of the concentrations observed for the three source locations in the Cortez Hills areas.

Acid-base Accounting Tests. The potential for acid generation from waste rock is quantified by calculating the Net Neutralization Potential (NNP), which is calculated from the percentage of carbonate carbon and the percentage of sulfide in the sample. BLM guidelines indicate that a rock with NNP greater than 20 is unlikely to generate acid (BLM 1996h). The acid-generating potential (AP) is calculated from the percentage of sulfide in the rock, and the acid-neutralizing potential (NP) of the rock is calculated from the percentage of carbonate carbon. BLM guidelines indicate that rocks with a NP/AP ratio greater than 3 are unlikely to generate acid. Rocks with NNP less than or equal to 20 or a NP/AP ratio less than or equal to 3 may not generate acid; however, additional testing of these materials may be required (BLM 1996h). ABA analysis samples were sent to a Nevada-certified analytical laboratory for determination of total sulfur, sulfate sulfur, and carbonate carbon. Sulfide sulfur was calculated for the samples by subtracting sulfate sulfur from total sulfur.

All 248 ABA samples obtained from the proposed North Gap Pit expansion area met or exceeded BLM guidelines to be considered net consumers of acid. Of the remaining Pipeline Pit ABA samples, 97 percent (526 samples) met or exceeded the guideline values. Fourteen samples did not meet the BLM's ABA guidelines; however, previous kinetic leach testing of these rock types (calcareous siltstone, skarn, silicified siltstone, and shear zone) indicated that leachate from these materials had near-neutral to mildly alkaline pH. As all samples from the North Gap Pit expansion area met or exceeded BLM guidelines, it is likely that all waste rock generated from the North Gap Pit would not be acid generating. The mean NP/AP ratio for the Pipeline Pit area was 5,647:1, indicating that the waste rock facilities. Including backfill placed in the North Gap Pit expansion area, would have large masses of carbonate available to neutralize any acid that could be produced by sulfide oxidation.

The majority of the 779 ABA samples from the area of the proposed Cortez Hills Pit and underground workings met BLM guidelines, indicating that the waste rock would be unlikely to be acid-producing. The mean NP/AP ratio for the Cortez Hills area was 6,036:1, indicating that the waste rock facilities would have large masses of carbonate available to neutralize acid that could be produced by sulfide oxidation. All but three out of 157 samples from the area of the proposed underground workings met both guidelines, and all but 23 out of 622 samples from the proposed Cortez Hills Pit area met both guidelines. The 26 samples that did not meet both guidelines consisted of limestone (including ore samples), dike, and refractory rock. Dike and refractory rock constitute only 1.2 and 0.3 percent, respectively, of the total waste rock mass for Cortez Hills; limestone represents 83 percent of the total waste rock mass. These three rock types were selected for additional kinetic testing.

Kinetic Testing. Both humidity cell and column leach tests were conducted on waste rock samples from the Cortez Hills areas. These results were combined with data from previous kinetic testing of samples from the Pipeline Pit area to provide a description of the time-varying chemistry of waste rock leachate (Geomega 2007c). In previous studies, the column leach test results were found to be a more conservative method of evaluating waste rock leachate, because higher constituent concentrations were observed in the effluents from these tests than from humidity cell or field oxidation tests.

Humidity cell tests were carried out according to standard practices (Sobek et al. 1978). Particle sizes were less than 2 millimeters in diameter, with a simulated humid environment consisting of 3 days of dry air circulation, followed by humid air circulation for 3 days. On the seventh day, airflow was stopped, the cell contents were leached with deionized water, and the leachate was filtered and analyzed. This weekly cycle was repeated for a minimum of 20 weeks. Leachate from tests with three Pipeline Pit samples and one Cortez Hills sample exhibited either rising trends or had effluent concentrations above applicable water quality standards for some analytes at 20 weeks. These tests were continued until the analyte concentrations exhibited a declining trend. These samples and the analytes of interest included a skarn waste rock sample (manganese and zinc) and two carbonaceous siltstone samples (manganese and zinc in one test, selenium in the other) from the proposed North Gap Pit expansion area and a refractory rock sample (arsenic) from the Cortez Hills Pit area.

The leachate pH values ranged from 6.4 to 9.5 and did not vary substantially with NNP. Sulfate concentrations were generally low, with 99 percent of the analyses less than 50 mg/L, and tended to decrease with leached pore volume. All fluoride, iron, and mercury concentrations measured in the humidity cell leachates were below their respective drinking water standards. The majority of manganese concentrations were below the secondary drinking water standard of 0.1 mg/L, and manganese concentrations were lower than in the background groundwater. Aluminum exceeded the secondary standard of 0.2 mg/L in only two of the 355 humidity cell leachate samples, and all other samples were consistently below the standard. Three apparently anomalous antimony concentrations were observed above drinking water quality standards; however, most antimony concentrations were below the method detection limits of 0.001 and 0.003 mg/L.

Arsenic concentrations in the humidity cell leachates ranged up to 0.563 mg/L, with 91 percent of the samples below the Nevada MCL of 0.05 mg/L. The highest arsenic concentrations were observed in leachates from the Pipeline Pit calcareous siltstone and from the Cortez Hills refractory rock type. These rock types represent less than 0.1 and 0.3 percent of the waste rock in their respective areas. Only the leachate from one humidity cell (AAC-0153, Cortez Hills refractory rock) remained above the Nevada arsenic standard at the end of testing, although the arsenic concentration was exhibiting a declining trend. The Nevada drinking water quality standard for selenium of 0.05 mg/L was consistently exceeded only by leachates from a single sample of Pipeline carbonaceous siltstone (P9CBN#2). This rock sample represented an extreme in terms of whole rock metals chemistry, and represents less than 0.1 percent of the waste rock that would be placed in the waste rock facilities.

Thirteen column tests were conducted with core hole samples representative of the various lithologies associated with the Pediment and Cortez Hills deposits. Deionized water was used to leach the crushed sample materials in the columns, and filtered effluent samples were analyzed. The column tests were conducted until chemical stability was achieved and at least 20 pore volumes had passed through the samples. Leachate solute concentrations in the column samples were below Nevada drinking water standards except for arsenic, aluminum, and mercury. Average antimony concentrations in the leachates were 0.003 mg/L, which equals the average background concentration in Cortez Hills bedrock wells (Geomega 2007c), and antimony concentrations declined to low concentrations with increasing pore volume. Peak concentrations of aluminum above the drinking water standard were observed in a few samples; however, these concentrations only were observed in a few tests and declined to below Nevada drinking water standards after two pore volumes. Mercury concentrations were observed above drinking water standards in two Cortez Hills dike samples and one Cortez Hills alluvium sample. Mercury concentrations in the effluents from these tests declined to below the drinking water standard over time. These samples represent rock types that would comprise 4.2 percent of the total waste rock mass from the Cortez Hills Pit.

Arsenic concentrations exceeded the Nevada drinking water standard (0.05 mg/L) after the passage of six pore volumes in five column tests with waste rock material from the Pediment and Cortez Hills deposits. One sample representative of Pediment siltstone conglomerate continued to leach arsenic above the Nevada standard through 48 pore volumes; this material would represent less than 4 percent of the total Cortez Hills Pit waste rock. Two samples representing the Cortez Hills dike rock type continued to leach arsenic at concentrations greater than 0.05 mg/L through 126 and 318 pore volumes, respectively. The dike rock type would represent 1 percent of the total Cortez Hills Pit waste rock.

Field tests of oxidation under ambient precipitation and evaporation conditions were carried out at the proposed project site. Samples were placed in plastic buckets modified to permit drainage and collection of water from precipitation events that occurred at the site. Analyte concentrations measured after five precipitation events generally were slightly lower than those measured in the humidity cell leachates. One sample analysis exceeded the Nevada standard for arsenic (0.05 mg/L).

3.2.1.5 Water Rights

An inventory of active water rights in the region surrounding the proposed project was used to identify the location and status of water rights within potentially affected areas (Geomega 2006f). The inventory was based on water rights records on file with the Nevada Division of Water Resources (NDWR). The inventory identified all active water rights located within the southern portion of the HSA including the approximate southern half of the Crescent Valley Hydrographic Area and adjacent areas of the Grass Valley and Pine Valley hydrographic areas within the HSA. For the purpose of the EIS analysis, all groundwater rights owned by CMG were excluded from this summary. The boundary of the inventory area and locations of the points of diversion for these water rights are shown in **Figure 3.2-9**; the owners, beneficial use, and annual duty for the each water right are summarized in **Table B-2** in Appendix B. Based on the NDWR database, there are a total of 89 active water rights in the inventoried area, which includes 81 surface water rights and 8 groundwater rights. The primary uses for water in the area are stock watering, irrigation, and mining and milling. Since water rights are not necessary for most domestic wells, this summary may not include all wells that exist within the inventoried area.

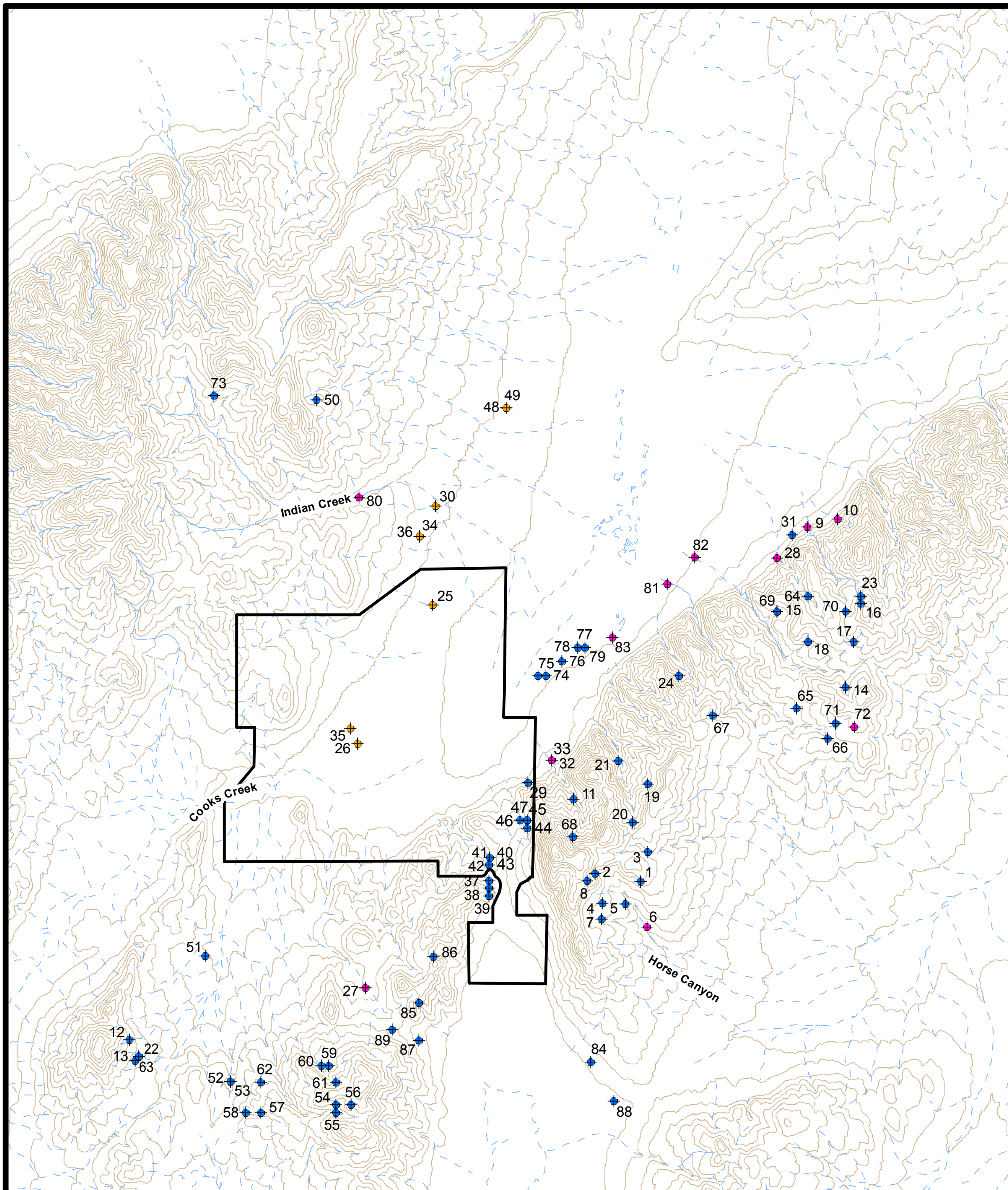
3.2.2 Environmental Consequences

The primary issues related to water resources include: 1) reduction in surface and groundwater quantity for current users and water-dependent resources from pit dewatering and production well withdrawal; 2) impacts to groundwater and surface water quality from the construction, operation, and closure of mineral processing mills, tailings storage facilities, heap leach facilities, waste rock storage facilities, and other mining and processing facilities; 3) impacts from flooding, erosion, and sedimentation associated with mine construction, operation, or closure activities; and 4) impacts related to the water quality of the post-mining pit lakes.

Impacts to water resources would be significant if the Proposed Action or other alternatives result in the following:

Surface Water

- Measurable reduction in the baseflow of perennial streams or perennial spring flows.
- Degradation of the quality of surface water based on applicable state or federal regulations for designated or appropriate beneficial uses, including, but not limited to, municipal or domestic water supply; irrigation; livestock watering; or support of terrestrial, avian, and aquatic life.
- Alteration of drainage patterns or channel geometry resulting in accelerated erosion and sedimentation.
- Measurable reduction of seasonal surface flows caused by withdrawal of contributing watershed area or by channel blockages, if important for biological resources.
- Damage to project facilities and on and off site resources during operation or post-closure as a result of inadequate drainage control features.



Legend

Project Boundary

Private Active Water Rights (See **Table B-2** in Appendix B)

- Groundwater
- Stream
- Spring

Source: Geomega 2006f.

Cortez Hills
Expansion Project

Figure 3.2-9
Private Active Water Rights

06/20/2007

Groundwater

- Reduction of static groundwater levels that could adversely affect water supply, agricultural, or industrial wells caused by project dewatering or post-mining pit lake development.

- Degradation of groundwater quality downgradient from the project facilities such that one or more water quality constituents would exceed Nevada or federal primary or Nevada secondary MCLs established to protect human health from potentially toxic or undesirable substances in drinking water, or where the quality of the groundwater already exceeds the MCLs for drinking water, the quality would be lowered such that it would render those waters unsuitable for other existing or potential beneficial use.

Potential impacts associated with dewatering-induced ground subsidence are addressed in Section 3.1.2, Geology and Minerals. Other potential impacts to wetlands and riparian areas are discussed in Section 3.4.2, Vegetation. Potential impacts resulting from the transportation, storage, and use of hazardous substances are addressed in Section 3.17.2, Hazardous Materials. Potential effects to Native American uses of streams and springs are addressed in Section 3.9, Native American Traditional Values.

3.2.2.1 Evaluation Methodology

This section provides a summary of the methods used to evaluate: 1) changes in groundwater elevations (drawdown and mounding), 2) post-mining pit lake development, and 3) pit lake water quality.

Numerical Flow Modeling. A calibrated three-dimensional numerical groundwater flow model was developed to estimate effects to groundwater and surface water resources from the Proposed Action, Cortez Hills Complex Underground Mine Alternative, and No Action Alternative; and the cumulative effects of historic dewatering and projected future dewatering and water management activities for this EIS. Specifically, the numerical model was used to evaluate or estimate: 1) mine dewatering rates required throughout the mine life; 2) areal extent, magnitude, and timing of drawdown and recovery of groundwater levels through the mining and post-mining periods; 3) development of post-mining pit lakes, groundwater inflow and outflow through the pits, and final surface water elevations of the pit lakes; 4) potential changes in the water balance in the Crescent Valley, Grass Valley, and Pine Valley hydrographic areas; and 5) potential changes in flow in the Humboldt River. Separate model runs were not conducted for the Grass Valley Heap Leach Alternative or Crescent Valley Waste Rock Alternative as the dewatering and water disposal operations would be the same as under the Proposed Action.

Geomega (2006b, 2007f) conducted the numerical groundwater modeling using an enhanced version of the USGS groundwater flow program MODFLOW (McDonald and Harbaugh 1988) known as MODFLOW-SURFACT (HydrogeoLogic 1996). MODFLOW-SURFACT contains many improvements over MODFLOW including enhanced simulation capabilities for handling complex field conditions (including simulating large groundwater elevation fluctuations resulting in drying and wetting of grid cells). MODFLOW originally was designed to simulate flow through porous media. MODFLOW models have been used to simulate groundwater flow in bedrock aquifers where flow through the bedrock system is controlled by interconnected fracture networks that behave similarly to porous media flow.

The groundwater flow model for the proposed project represents an expansion of the previous model developed for the Crescent Valley region for the existing Pipeline Pit. Earlier versions of the groundwater model for the Crescent Valley region were calibrated to evaluate potential effects to groundwater and surface water resources associated with mine dewatering and water management activities for the original Pipeline Pit (BLM 1996a), and subsequent South Pipeline and Pipeline/South Pipeline Pit expansions (BLM 2000a, 2004e). In addition, in accordance with BLM requirements for the existing project, the groundwater model has been updated and recalibrated on an annual basis since 1998 (most recently, Geomega 2006b, 2007f).

The groundwater model domain encompasses the entire HSA as shown in **Figure 3.2-1.** The numerical groundwater model contains 25 horizontal layers to simulate the vertical range extending from 9,600 feet amsl to 1,550 feet below mean sea level. In order to provide more detailed flow information in the project area, the grid cell dimensions vary horizontally from 10,000 feet by 10,000 feet at the outer margins of the model to 200 feet by 200 feet in the mine area. The more detailed discrete grid cells in the mining area allow the model to more accurately match observed hydrologic features (such as fault zones and steep hydraulic gradients, well locations, mine pit geometry, and groundwater levels) in the project vicinity. A detailed explanation of the conceptual hydrogeologic model, modeling approach and setup, steady-state and transient calibrations, sensitivity analysis, optimization, and simulations is presented in Geomega's groundwater model technical report (2007f).

Pit Dewatering and Water Management Activities. Historic dewatering rates and projected future dewatering requirements are summarized in **Table 3.2-9** and shown in **Figure 3.2-10**. Active dewatering for the Pipeline Pit was initiated in 1996 and has continued uninterrupted through the present (end of 2006). The average annualized pumping rate between 1996 through 2006 varied from approximately 3,800 to 28,100 gpm. (Note that the total estimated future dewatering requirements under the Grass Valley Heap Leach Alternative and Crescent Valley Waste Rock Alternative would be the same as under the Proposed Action.)

Dewatering is projected to continue under currently permitted activities included in the No Action Alternative through 2013 (Geomega 2007f). Under the No Action Alternative, the final target elevation for dewatering at the Pipeline Pit is 3,400 feet amsl; this represents a total drawdown of approximately 1,300 feet. The No Action alternative also includes the currently permitted dewatering and water management activities associated with the Cortez Underground Exploration Project. Dewatering was initiated for the underground exploration project in early 2006 and is projected to continue through 2011. The target dewatering elevation for the underground exploration project is 4,100 feet amsl, which would represent a total maximum drawdown in the mine area of approximately 800 feet. Under the No Action Alternative, the total future dewatering requirements for the project would range from 28,100 to 34,800 gpm.

Under the Proposed Action, no change in the currently permitted dewatering program at the Pipeline Complex would occur. The active dewatering period for the Cortez Hills area would be extended several years (depending on the actual start-up date), and the target dewatering elevation would be lowered to 3,800 feet amsl (for a total drawdown of approximately 1,600 feet) to allow for development of the proposed Cortez Hills Pit and development of the underground mine operation. The results of the numerical groundwater modeling indicate that the dewatering requirements under the Proposed Action would increase

Table 3.2-9
Summary of Historic and Estimated Future Dewatering Requirements[1]

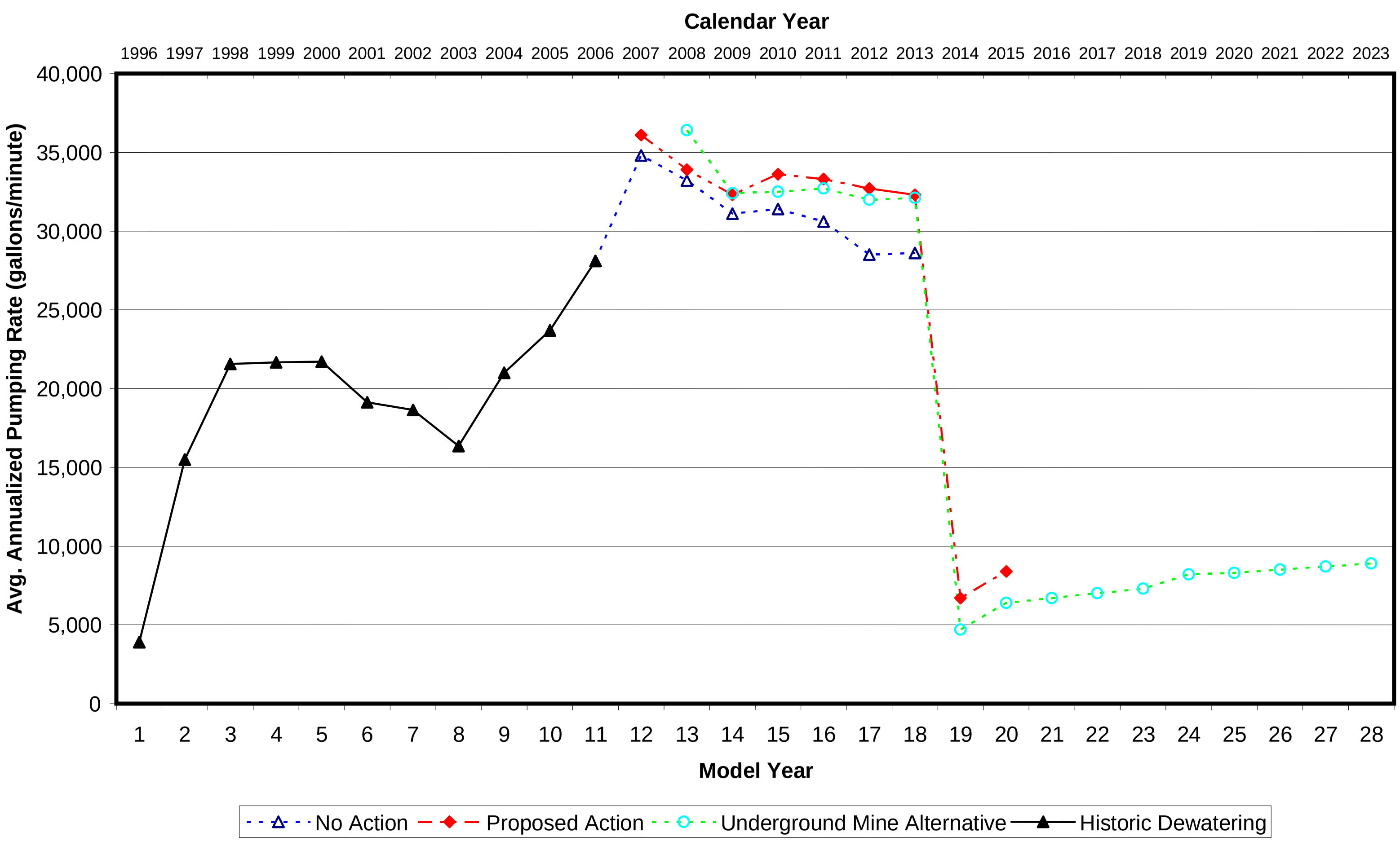
			Total Estimated Future Dewatering Requirements			Incremental Increase In Pumping	
Model Year	Calendar Year[2]	Historic Pumping (gpm)	No Action Alternative[3] (gpm)	Proposed Action[4] (gpm)	Cortez Hills Complex Underground Mine Alternative[5] (gpm)	Proposed Action (gpm)	Cortez Hill Complex Underground Mine Alternative (gpm)
1	1996	3,885					
2	1997	15,501					
3	1998	21,563					
4	1999	21,656					
5	2000	21,718					
6	2001	19,130					
7	2002	18,643					
8	2003	16,356					
9	2004	21,005					
10	2005	23,700					
11	2006	28,100	28,100				
12	2007		34,800	36,100		1,300	
13	2008		33,200	33,900	36,400	700	3,200
14	2009		31,100	32,300	32,400	1,200	1,300
15	2010		31,400	33,600	32,500	2,200	1,100
16	2011		30,600	33,300	32,700	2,700	2,100
17	2012		28,500	32,700	32,000	4,200	3,500
18	2013		28,600	32,300	32,100	3,700	3,500
19	2014			6,700	4,700	6,700	4,700
20	2015			8,400	6,400	8,400	6,400
21	2016				6,700		6,700
22	2017				7,000		7,000
23	2018				7,300		7,300
24	2019				8,200		8,200
25	2020				8,300		8,300
26	2021				8,500		8,500
27	2022				8,700		8,700
28	2023				8,900		8,900

Note: The total estimated future dewatering requirements and incremental increase in pumping under the Grass Valley Heap Leach Alternative and Crescent Valley Waste Rock Alternative would be the same as under the Proposed Action.

[1] Average annual flow rate.
[2] Calendar years used for numerical groundwater flow model simulations; actual startup dates for the Proposed Action or Cortez Hills Complex Underground Mine Alternative would depend on BLM and NDEP authorizations. Current estimates assume that the earliest either operation would start would be mid-year 2008 (see Sections 2.4, Proposed Action, and 2.5.1.4, Cortez Hills Complex Underground Mine Alternative).
[3] Currently authorized dewatering rates for the existing Pipeline Pit.
[4] Includes currently authorized dewatering rates for the existing Pipeline Pit and proposed dewatering for the Cortez Hills Pit and underground operation.
[5] Includes currently authorized dewatering rates for the existing Pipeline Pit and proposed dewatering for the underground operation.

Source: Geomega 2006b, 2007f.

Figure 3.2-10. Historic Mine Dewatering and Total Estimated Future Dewatering Requirements



Note: The total estimated dewatering requirements under the Grass Valley Heap Leach Alternative and Crescent Valley Waste Rock Alternative would be the same as under the Proposed Action.

Source: Geomega 2007d,f.

the total estimated dewatering rate for the project to a maximum of 36,100 gpm. The incremental increase in pumping attributable to the Proposed Action (compared to currently permitted operations included in the No Action Alternative) ranges from 700 to 8,400 gpm (on an average annual basis) with the highest incremental rates occurring in the final years of operation (after active dewatering for the Pipeline Complex ceases) (**Table 3.2-9**). The increased dewatering requirements under the Proposed Action also are estimated to result in an increase in the volume of water delivered to the infiltration basins for reinfiltration to the basin fill aquifer in Crescent Valley (**Table 3.2-10**). The excess water produced under the Proposed Action would be conveyed via the previously authorized pipeline to the existing water management system for the Pipeline/South Pipeline Project. The existing water management system includes a conveyance system to transfer excess mine dewatering water to the infiltration basins or to the Dean Ranch for use in crop irrigation. No new infiltration basins or increases in crop irrigation are included in the Proposed Action. The proposed dewatering would extend mine dewatering and water management activities several years beyond the previously authorized activities described under the No Action Alternative.

The dewatering scenario modeled for the Cortez Hills Complex Underground Mine Alternative represents the total dewatering requirements for all previously authorized and projected future activities for the Pipeline/South Pipeline and Cortez Underground Exploration projects, (included in the No Action Alternative) and additional dewatering requirements for development of the underground mining operation. The final target dewatering elevation in the Cortez Hills area is 3,800 feet (1,600 feet of drawdown), which is the same as the Proposed Action. The final target dewatering elevation for the Pipeline Complex is the same as for the No Action Alternative. The estimated dewatering rates and duration of dewatering required under this alternative is provided in **Table 3.2-9**. As shown in **Figure 3.2-10**, the dewatering requirements for the Cortez Hills Complex Underground Mine Alternative would be similar to the Proposed Action and would increase the total estimated dewatering rate for the project to a maximum average annualized rate of 36,100 gpm. However, as shown in **Table 3.2-9**, the underground mine alternative would extend the period of dewatering an additional 8 years (Geomega 2007f) compared to the Proposed Action.

The cumulative impacts associated with mine dewatering and water management activities include an evaluation of the total drawdown from all past, present, and reasonably foreseeable future mine dewatering and water management activities. This includes: 1) historic dewatering activities initiated in 1996 and continuing through the present, and 2) projected future total dewatering required necessary for the currently permitted operations and increased dewatering requirements for the Proposed Action. The historic dewatering rates and projected future dewatering rates used in the cumulative analysis are presented in **Table 3.2-9** and **Figure 3.2-10**.

Evaluation of Impacts to Groundwater Levels. Impacts to groundwater levels were evaluated using the results of the numerical modeling for the different mine dewatering scenarios discussed above. For the Proposed Action, No Action Alternative, and Cortez Hills Complex Underground Mine Alternative dewatering scenarios, the projected changes in groundwater levels represent the difference between the model-simulated groundwater elevations and simulated baseline groundwater elevations that existed the end of 2004 (**Figure 3.2-11**). For this reason, the modeling simulations for the Proposed Action do not include the changes to groundwater elevations that have occurred in the project area due to the historic pumping and water management activities that occurred between 1996 and the end of 2004. For the

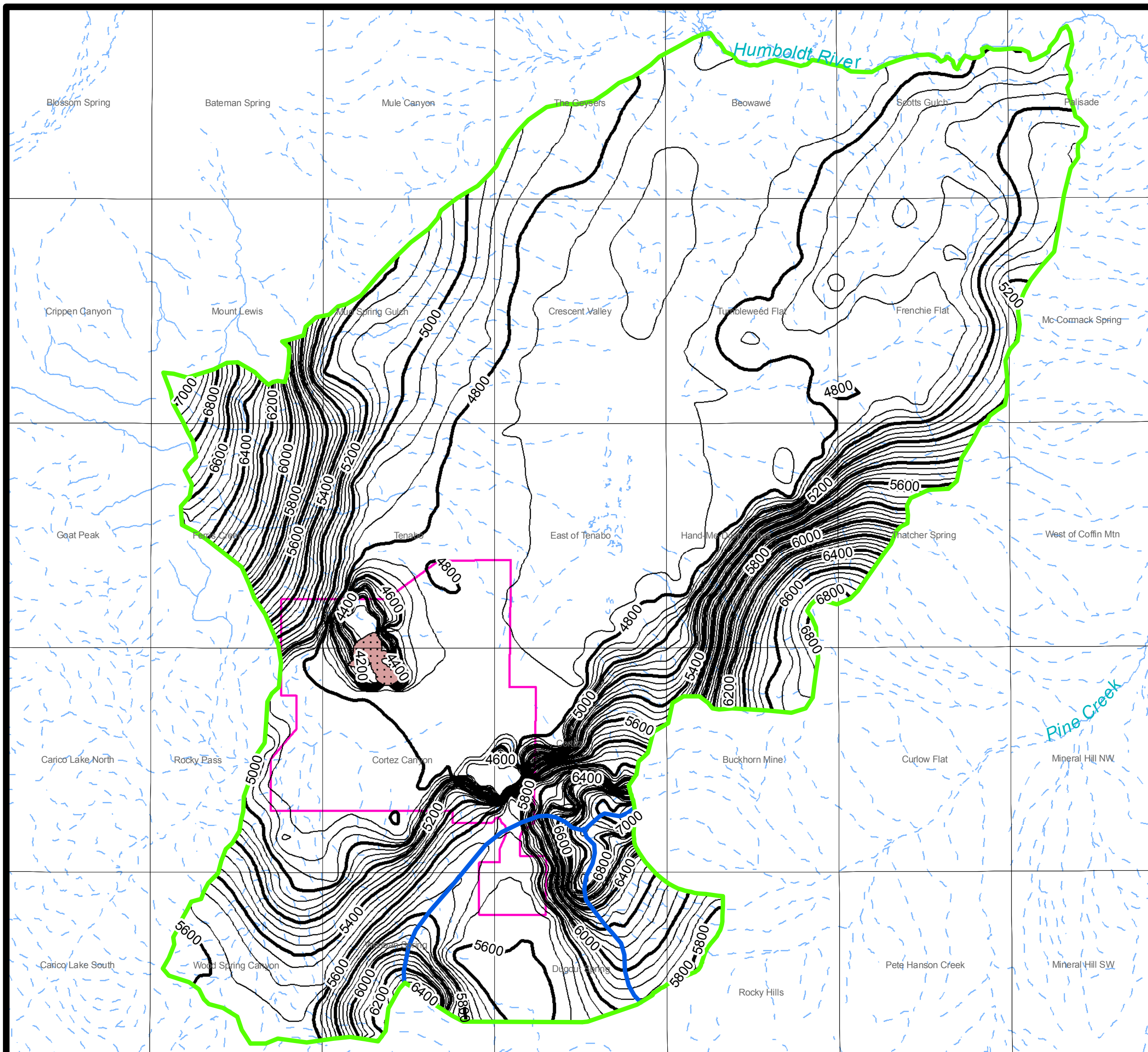
Table 3.2-10
Summary of Historic and Estimated Future Infiltration Requirements

			Total Future Basin Infiltration						Incremental Increase In Infiltration			
Calendar Year	Model Year	Historic Reinfiltration acre-feet	No Action[2]		Proposed Action[3]		Cortez Hills Complex Underground Mine Alternative		Proposed Action		Cortez Hills Complex Underground Mine Alternative	
			gpm[1]	acre-feet	gpm[1]	acre-feet	gpm[1]	acre-feet	gpm[1]	acre-feet	gpm[1]	acre-feet
1996	1	6,499										
1997	2	22,017										
1998	3	33,229										
1999	4	32,483										
2000	5	31,737										
2001	6	28,414										
2002	7	25,561										
2003	8	21,511										
2004	9	26,077										
2005	10	27,402										
2006	11	27,555										
2007	12		24,800.00	40,009.84	26,100.00	42,107.13			1,300.00	2,097.29		
2008	13		23,200.00	37,428.56	23,900.00	38,557.87	26,400.00	42,591.12	700.00	1,129.31	2,000	5,162.56
2009	14		21,100.00	34,040.63	22,300.00	35,976.59	22,400.00	36,137.92	1,200.00	1,935.96	100	2,097.29
2010	15		21,400.00	34,524.62	23,600.00	38,073.88	22,500.00	36,299.25	2,200.00	3,549.26	100	1,774.63
2011	16		20,600.00	33,233.98	23,300.00	37,589.89	22,700.00	36,621.91	2,700.00	4,355.91	900	3,387.93
2012	17		18,500.00	29,846.05	22,700.00	36,621.91	22,000.00	35,492.60	4,200.00	6,775.86	2,300	5,646.55
2013	18		18,600.00	30,007.38	22,300.00	35,976.59	22,100.00	35,653.93	3,700.00	5,969.21	2,300	5,646.55
2014	19				1,500.00	2,419.95	1,500.00	2,419.95	1,500.00	2,419.95	1,500	2,419.95
2015	20				1,500.00	2,419.95	1,500.00	2,419.95	1,500.00	2,419.95	1,500	2,419.95
2016	21						1,500.00	2,419.95			1,500	2,419.95
2017	22						1,500.00	2,419.95			1,500	2,419.95
2018	23						1,500.00	2,419.95			1,500	2,419.95
2019	24						1,500.00	2,419.95			1,500	2,419.95
2020	25						1,500.00	2,419.95			1,500	2,419.95
2021	26						1,500.00	2,419.95			1,500	2,419.95
2022	27						1,500.00	2,419.95			1,500	2,419.95
2023	28						1,500.00	2,419.95			1,500	2,419.95
Total Volume		**282,485**		**239,091**		**267,324**		**246,996**		**28,233**		**47,951**
Total (Cumulative) Volume Reinfiltrated		**282,485**		**521,576**		**549,809**		**529,481**				

Note: Estimated future infiltration requirements under the Grass Valley Heap Leach Alternative and Crescent Valley Waste Rock Alternative would be the same as under the Proposed Action.

[1] Average annual flow rate.
[2] Infiltration rates for existing operations.
[3] Infiltration rate for existing and proposed operations.

Source: Geomega 2007d,f.



Groundwater Table Contours:
- 50-foot Interval
- 200-foot Interval
- Groundwater Divide
- Model Domain
- Stream (dashed where intermittent)
- Project Boundary
- Pipeline Pit

N

0 1 2 4 Miles

Source: Geomega 2007f.

Cortez Hills Expansion Project

Figure 3.2-11
Simulated Groundwater Table - December 2004

06/19/2007

cumulative analysis, the total change in groundwater elevations resulting from both the historic and projected future total dewatering operations under the Proposed Action dewatering scenario were evaluated. In addition, the baseline conditions used as the reference for comparison for the cumulative analysis is the estimated pre-mining steady-state groundwater elevations that existed prior to initiation of dewatering in 1996.

In addition, the magnitude, timing, and areal extent of drawdown was evaluated by analyzing the model simulation results at four selected time intervals that represent the projected conditions at the end of mine dewatering and at 25 years, 50 years, and 100 years after dewatering ceases under each of the dewatering scenarios. It is important to note that the end of dewatering is estimated to occur at different points in time for the different alternatives as shown in **Figure 3.2-10**. For example, the model simulations assumed that the end of dewatering for the Proposed Action would occur approximately 2 years after dewatering would cease under the No Action alternative. Likewise, the model simulations assumed that the end of dewatering for the Cortez Hills Complex Underground Mine Alternative would occur approximately 10 years after dewatering would cease under the No Action Alternative.

Evaluation of Impacts to Water Resources. For this impact analysis, the area that is predicted to experience a change in groundwater elevation of 10 feet or more as a result of mine dewatering and water management activities was selected as the area of potential concern regarding potential impacts to water resources. Changes in groundwater levels of less than 10 feet generally are difficult to distinguish from natural seasonal and annual fluctuations in groundwater levels.

Impacts to water resources are presented for each of the alternative dewatering scenarios discussed previously. The Proposed Action and the Cortez Hills Underground Mining Alternative also include a discussion of the incremental increase in potential impacts to water resources that would occur compared to the currently permitted dewatering activities included in the No Action Alternative.

Pit Lake Water Quality Evaluation. A hydrochemical evaluation of pit lake water quality under the Proposed Action and No Action Alternative was performed by Geomega (2007a). In this evaluation, the modeled processes included the quality and quantity of groundwater inflow and outflow, pyrite oxidation rates in exposed wall rock, chemical releases from oxidized wall rock and waste rock, aqueous geochemical reactions in the pit lakes, evaporation from the pit lake surfaces, direct precipitation into the pit lakes, runoff from pit walls, and exchange of carbon dioxide (CO_2) between the pit lakes and the atmosphere.

The ultimate surface of each pit lake was determined, along with the lithology and geochemistry of the exposed wall rock. This information was used to develop a geologic block model of the exposure of each rock type in each pit surface. Backfilling of underground workings under the various alternatives also was evaluated as part of this analysis. The volume of the underground workings beneath the pit bottom was calculated, and the lithology of the exposed rock was characterized. This information was used to simulate the release of solutes to the pit lake from the underground workings.

The chemistry of the lithologic units exposed on the ultimate pit surface rock were characterized using whole-rock chemical analyses, and the acid-generation potential of these units was evaluated using ABA analyses, as described in Section 3.2.1.4, Waste Rock Characterization. The results of the ABA analyses indicated that nearly all of the ultimate pit surface rock would be non-acid-generating. The pit surfaces are expected to contain large masses of carbonates to buffer any acid produced by sulfide oxidation. Whole rock chemistry data indicated that the ultimate pit surface rock compositions in the proposed North Gap Pit expansion and the existing Pipeline Pit would be very similar. As a result, the results of kinetic testing on waste rock from the Pipeline Pit is expected to be representative of rock exposed at the ultimate pit surface of the North Gap Pit expansion. The chemical compositions of rocks exposed in the proposed Cortez Hills Pit are expected to be similar to the compositions of rocks exposed in the Cortez Pit and the underground workings. The ranges of analyte concentrations for samples selected for kinetic testing span a reasonable range of the concentrations anticipated for the Cortez Hills Pit. As a result, the samples selected for kinetic testing are representative of the rocks that would be exposed in the Cortez Hills Pit ultimate pit surface, underground workings, and Cortez Pit ultimate pit surface.

Blasting and excavation during open-pit mining exposes mineralized rock to the atmosphere. This exposed rock may react under atmospheric conditions, leaching solutes during contact with incident precipitation or groundwater discharge through the wall rock. The depth of the wall rock disturbance generally is estimated to be within approximately 5 feet of the ultimate pit surface. The volume of oxidized wall rock over time depends on the pyrite content, wall fracture density, rock porosity, wall rock moisture content, rate of oxygen diffusion into the wall rock, and the time during which the wall rock is exposed to oxygen before inundation by the pit lake water. These factors were used to calculate the depth of wall rock oxidation as a function of time for the pit lake model. The empirical solute release functions were applied to this entire volume of wall rock. As waste rock would be placed below the groundwater table in both the Pipeline Pit and in the underground workings at Cortez, it was assumed that this translocated waste rock would leach constituents into the pit lakes. The F-Canyon Pit, which also would contain waste rock backfill, is above the groundwater table and was not included in the pit lake evaluation.

Leachate chemistry of waste rock was characterized using humidity cell (kinetic) testing, column testing, and field oxidation tests; the results of these tests were discussed in Section 3.2.1.4, Waste Rock Characterization. These results were used to develop functions describing the time-varying release of solutes from the oxidized wall rock units to the pit lakes. The leachates had mildly alkaline pH, with reasonably low TDS and metals concentrations. These results are consistent with the pit lake water quality measurements from the former Cortez Pit lake, which had a moderate pH and water quality that was similar to background groundwater (Section 3.2.1.3, Groundwater Resources).

The background groundwater chemistry in the area of the existing Pipeline Pit and the existing Cortez Pit was described in Section 3.2.1.3, Groundwater Resources. Monitoring wells near the existing Gap and Crossroads portions of the Pipeline Pit were categorized according to the lithologic unit in which they were screened, to allow for identification of the groundwater chemistry that would discharge through each unit into the pit. In the area of the Cortez Hills and Cortez pits, the lithological units are more localized or discontinuous; as a result, data from monitoring wells in this area were used to develop a single background groundwater chemistry for all rock types.

The quantities of water entering the pit lakes were estimated from meteoric precipitation data and estimates of the volume of surface runoff from the pit walls, evaporative losses, and flow velocities and pit water levels predicted by the groundwater flow model. The chemical inputs to the pit lakes were predicted based on background groundwater chemistry, chemical release functions, amounts of translocated waste rock in the pits, and estimated thicknesses of the oxidized wall rocks. These contributions were calculated annually and used as input for geochemical modeling of the pit lake compositions as a function of time. At each time step, the geochemical modeling incorporated the effects of proportional mixing of influent and antecedent waters, evapoconcentration of the pit lake water, equilibration of the solutions with atmospheric gases (oxygen and CO_2), equilibration with potential or existing solid phases, computation of the mass of amorphous ferric hydroxide (AFH) and the sorption of solutes by AFH, and speciation of the resulting pit lake water. Details regarding the methodology used to predict pit lake quality are provided in the pit lake chemistry report for the project (Geomega 2007a).

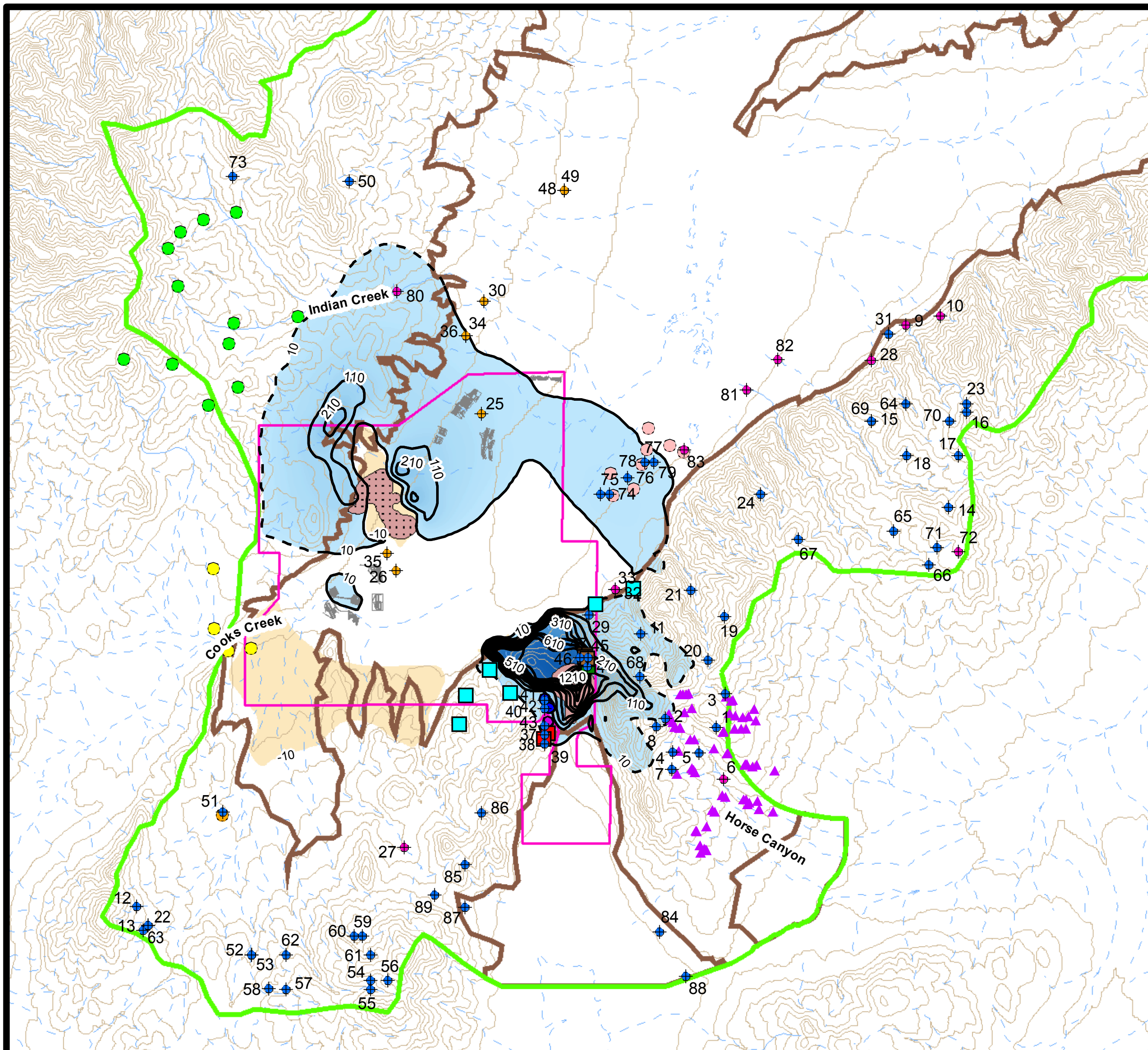
3.2.2.2 Proposed Action

Water Quantity Impacts

Impacts to Water Levels. The modeling simulations for the Proposed Action were based on the total mine dewatering requirements and water management activities that would occur in the future for the existing and proposed operations. As such, the modeling scenario incorporated the dewatering rates shown in **Figure 3.2-10** ranging from 36,100 in the first year of dewatering to 8,400 gpm in the final year of dewatering.

The predicted change in groundwater levels attributable to the total mine dewatering requirements under the Proposed Action at the end of dewatering, 25 years after dewatering, and 100 years after dewatering are provided in **Figures 3.2-12**, **3.2-13**, and **3.2-14**, respectively. These figures illustrate areas where the water levels are predicted to decrease or increase over time in comparison to the baseline groundwater elevations at the end of 2004. At the end of dewatering, two distinct drawdown areas are predicted to develop: one area centered on the Pipeline Complex and one area centered on the Cortez Hills Complex. In the vicinity of the Cortez Hills Pit, comparison of the three periods indicates that the maximum extent of the 10-foot drawdown contour is predicted to expand in the post-mining period until at least 100 years after dewatering ceases. The long-term expansion of the drawdown area would result in part from the continual inflow of groundwater from the surrounding area to the Cortez Hills Pit. The maximum area of drawdown (defined by the 10-foot contour) is predicted to extend beneath the Cortez Mountains into the Pine Valley Hydrographic Area, and into the northern portion of the Grass Valley Hydrographic Area. In addition, the hydrologic divide between Crescent Valley and Grass Valley is predicted to shift approximately 1 mile south compared to the baseline conditions (Geomega 2007e).

In Crescent Valley, at the end of dewatering (**Figure 3.2-12**), the drawdown in the basin fill aquifer is predicted to extend across to the east side of the valley. In addition, the water levels would increase in the southern part of Crescent Valley, south of the Pipeline Complex, in response to ongoing infiltration activities. Infiltration activities north of the mine complex also would restrict the drawdown northeast of the Pipeline Complex (Geomega 2007f). In the post dewatering period, the water levels would recover in the east side of the valley but the drawdown area would expand toward the northwest beneath the Shoshone Range in the vicinity of Indian Creek. The predictions for 25 years (**Figure 3.2-13**) and 100 years (**Figure 3.2-14**) after dewatering also indicate an expansion of the drawdown in Crescent Valley in areas located south and



Monitored Seeps and Springs
- Toiyabe Catchment
- Peripheral
- East Valley
- Shoshone
- Rocky Pass
- Cortez Canyon Seeps
- Mapped Cortez Canyon Spring
- NE Toiyabe Seeps
- NE Corner Seeps and Spring
- NE Survey Area Seep
- Horse Canyon Area

Private Active Water Rights (See **Table B-1** in Apppendix B)
- Groundwater
- Streams
- Springs

- Groundwater Level Contours (in feet, dashed where less certain)
- Infiltration Basins
- Elevation Contours (200-foot interval)
- Stream (dashed where intermittent)
- Model Domain
- Project boundary
- Cortez Hills Pit
- Pipeline Pit

Basin Fill - Bedrock Contact

Groundwater Level Decrease (in feet)
1000
10

Groundwater Level Increase (in feet)
-10
-1000

Note: Groundwater level changes compared to estimated groundwater levels at the end of 2004.

Source: Geomega 2007f.

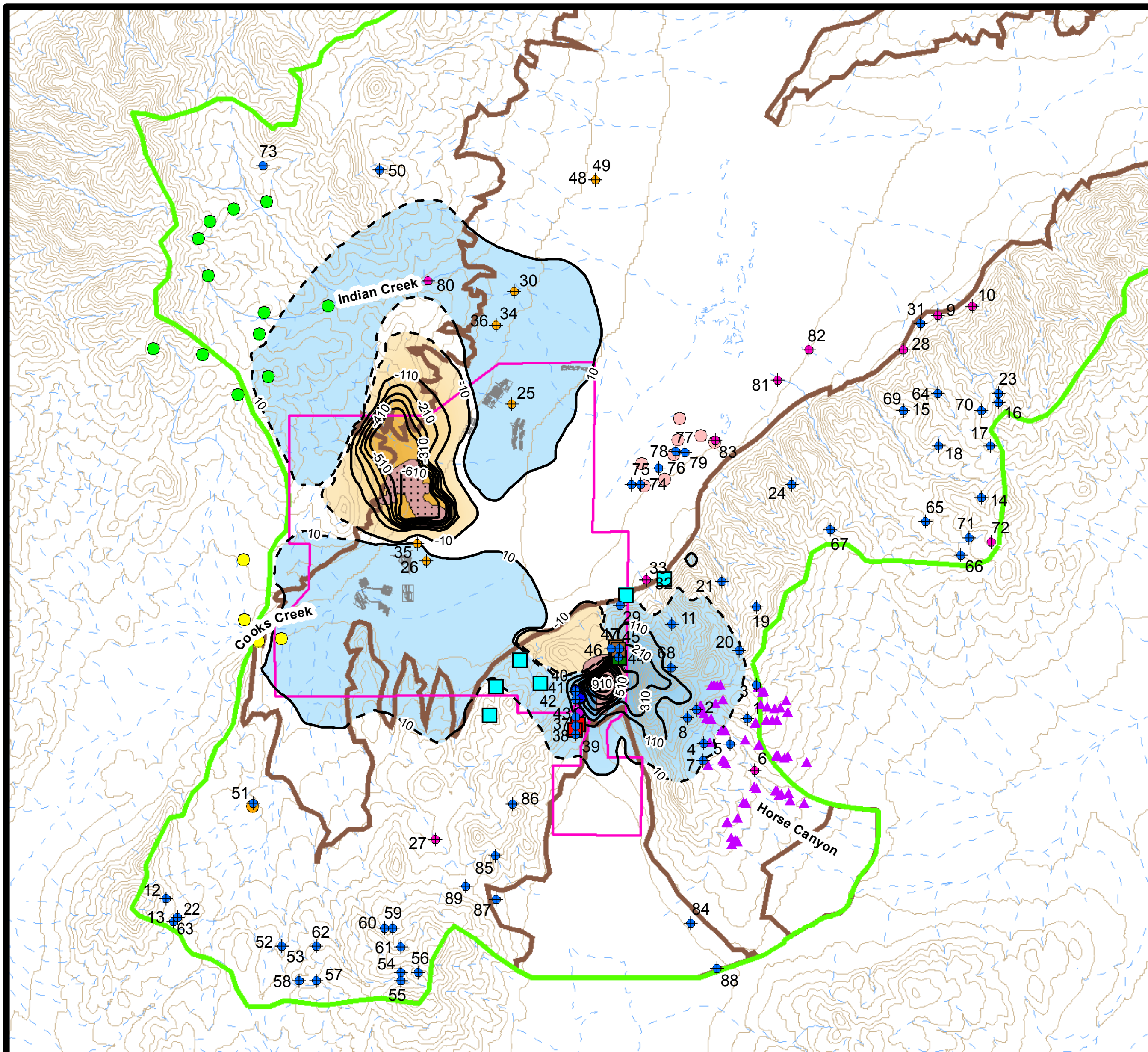
N

0 1 2 4 Miles

Cortez Hills Expansion Project

Figure 3.2-12
Proposed Action
Predicted Groundwater
Level Change -
End of Dewatering

06/19/2007



Monitored Seeps and Springs
- Toiyabe Catchment
- Peripheral
- East Valley
- Shoshone
- Rocky Pass
- Cortez Canyon Seeps
- Mapped Cortez Canyon Spring
- NE Toiyabe Seeps
- NE Corner Seeps and Spring
- NE Survey Area Seep
- Horse Canyon Area

Private Active Water Rights (See **Table B-1** in Appendix B)
- Groundwater
- Streams
- Springs
- Groundwater Level Contours (in feet, dashed where less certain)
- Infiltration Basins
- Model Domain
- Elevation Contours (200-foot interval)
- Stream (dashed where intermittent)
- Project Boundary
- Cortez Hills Pit
- Pipeline Pit

Basin Fill - Bedrock Contact

Groundwater Level Decrease (in feet)
1000
10

Groundwater Level Increase (in feet)
-10
-1000

Note: Groundwater level changes compared to estimated groundwater levels at the end of 2004.

Source: Geomega 2007f.

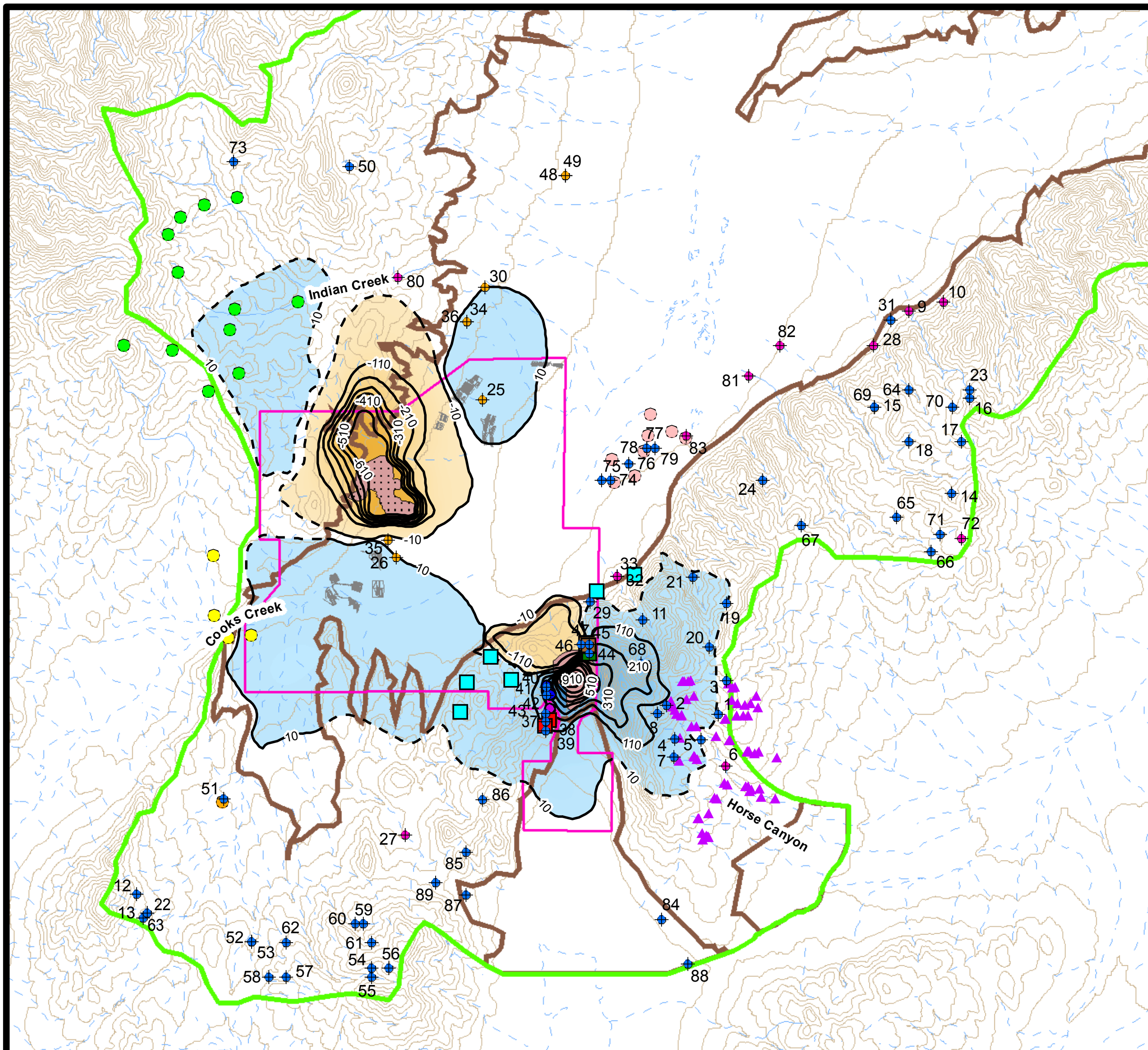
N

0 1 2 4 Miles

Cortez Hills Expansion Project

Figure 3.2-13
Proposed Action
Predicted Groundwater
Level Change - 25 Years
Post-dewatering

06/19/2007



Monitored Seeps and Springs
- Toiyabe Catchment
- Peripheral
- East Valley
- Shoshone
- Rocky Pass
- Cortez Canyon Seeps
- Mapped Cortez Canyon Spring
- NE Toiyabe Seeps
- NE Corner Seeps and Spring
- NE Survey Area Seep
- Horse Canyon Area

Private Active Water Rights (See **Table B-1** in Appendix B)
- Groundwater
- Streams
- Springs

- Groundwater Level Contours (in feet, dashed where less certain)
- Model Domain
- Infiltration Basins
- Elevation Contours (200-foot interval)
- Stream (dashed where intermittent)
- Pipeline Pit
- Project Boundary
- Cortez Hills Pit

Basin Fill - Bedrock Contact

Groundwater Level Decrease (in feet)
1000
10

Groundwater Level Increase (in feet)
-10
-1000

Note: Groundwater level changes compared to estimated groundwater levels at the end of 2004.

Source: Geomega 2007f.

N

0 1 2 4 Miles

Cortez Hills Expansion Project

Figure 3.2-14
Proposed Action
Predicted Groundwater
Level Change - 100 Years
Post-dewatering

06/19/2007

northeast of the Pipeline Complex. However, the drawdown in these two areas is an artifact of the baseline conditions used for the analysis (Geomega 2007f). Prior to December 2004, the water levels in these areas had increased due to mine infiltration activities. After infiltration activities cease, the groundwater mounds would dissipate, and water levels would be reduced to pre-mining conditions. Therefore, the apparent drawdown in these two areas results from dissipation of the groundwater mounds from prior infiltration activities and not from mine-induced drawdown.

Water levels are predicted to increase over time (compared to water levels at the end of 2004) in the vicinity of the Pipeline Complex in response to recovery of the central portions of the drawdown cone and filling of the pit lake that would occur after dewatering ceases. The initial recovery predicted in the Pipeline Complex at the end of dewatering reflects the assumption that active dewatering would cease at the Pipeline Complex approximately 2 years prior to the end of dewatering at the Cortez Hills Complex. Recovery also is predicted to increase water levels (compared to groundwater levels at the end of 2004) in the northeastern portion of the Cortez Window immediately northwest of the proposed Cortez Hills Pit, an area that experienced up to approximately 200 feet of drawdown prior to the end of 2004.

No drawdown is predicted to occur in the vicinity of Crescent Valley Township or in the northern portion of Crescent Valley in the vicinity of the Humboldt River (Geomega 2007f).

The incremental changes in groundwater levels attributable to the Proposed Action were evaluated by comparison to the model simulated water level changes for the No Action Alternative described in Section 3.2.2.4. The comparison at the various time intervals indicates that the drawdown predicted to occur beneath the Shoshone Range west and northwest of the Pipeline Pit, and in the Crescent Valley area north, west, and south of the Pipeline Pit, would be essentially the same for the Proposed Action as for the No Action Alternative. Therefore, the incremental increase in dewatering for the Proposed Action is not predicted to significantly affect water levels in these areas already projected to be impacted under the No Action Alternative. The Proposed Action would result in an increase in drawdown (compared to the No Action Alternative) in the east side of Crescent Valley (at the end of mining); and in the region surrounding the Cortez Hills Pit including the areas beneath the Cortez Mountains (at the end of mining and for the foreseeable future in the post-mining period).

Pit Lake Development. As shown in **Figure 2-8**, following the completion of mining and dewatering operations, groundwater elevations would rebound and eventually result in the development of pit lakes in both the Cortez Hills and Cortez pits. The predicted physical conditions for the pit lakes are summarized in **Table 3.2-11**; the rate of pit lake development is shown in **Figure 3.2-15**. The Cortez Hills Pit would recover rapidly from dewatering with more than 80 percent of the recovery occurring within 10 years of the end of dewatering. In addition, at 100 years post-mining, the Cortez Hills Pit is predicted to have groundwater outflow at an estimated rate of 200 acre-feet per year. The Cortez Pit lake is predicted to start to form at approximately 20 years after the end of dewatering (Geomega 2007e) due in large part to the higher elevation of the pit floor. The Cortez Pit lake is expected to behave as a sink, with no throughflow to the groundwater system.

Table 3.2-11
Summary of Predicted Pit Lakes at 100 Years Post-mining under the Proposed Action

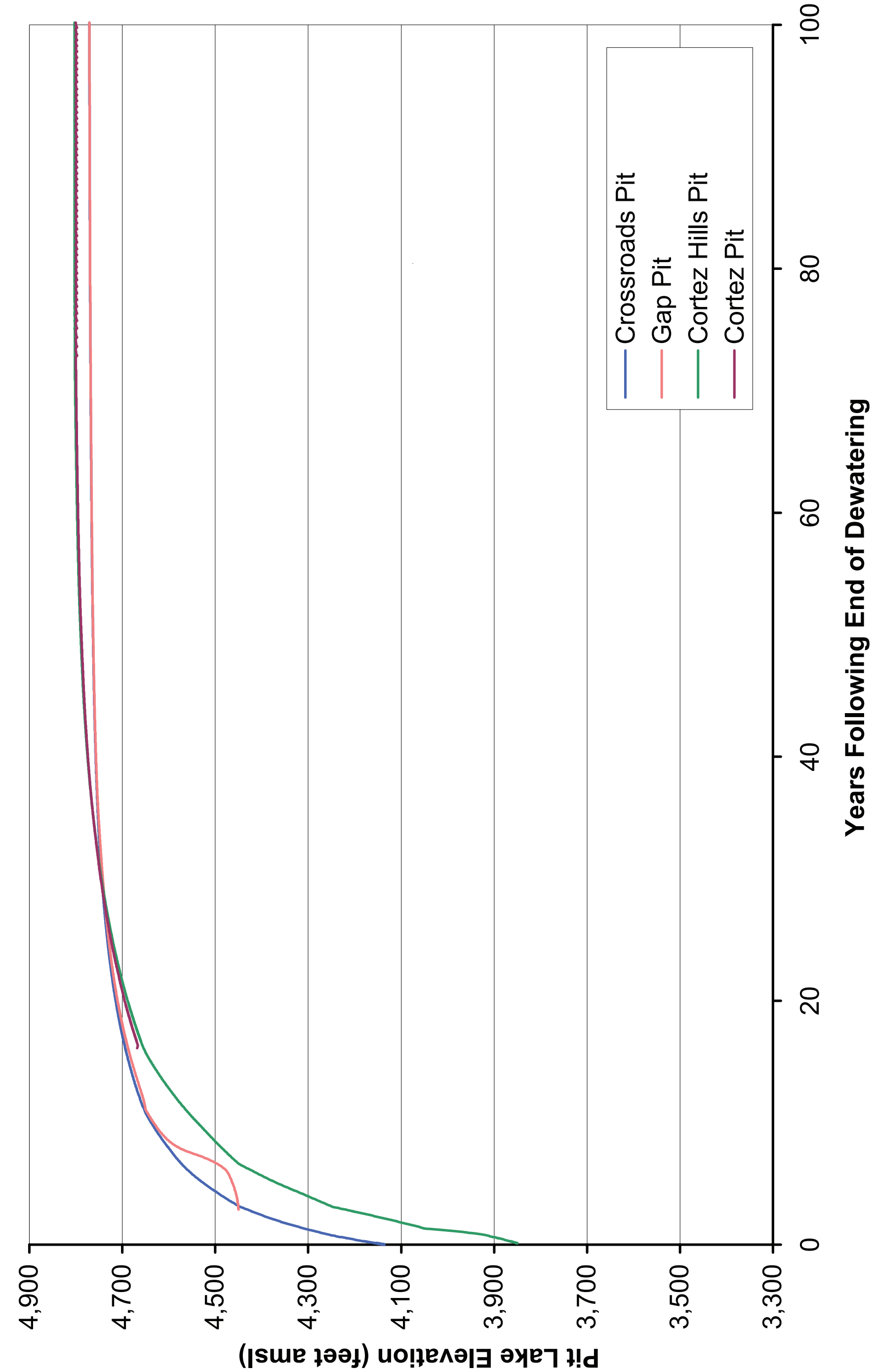
Pit Lake Location[1]	Surface Area (acre)	Volume (acre-feet)	Surface Elevation (feet amsl)	Pit Floor Elevation (deepest) (feet amsl)	Maximum Depth (feet)	Evaporative Loss (acre-feet/year)	Groundwater Outflow (Yes/No) (acre-feet/year)
Cortez Hills Pit	179	79,931	4,807	3,800	1,007	531	Yes 200
Cortez Pit	6	258	4,805	4,600	205	18	No
Crossroads Pit[2]	269	143,220	4,770	3,400	1,370	928	No
Gap Pit[2]	33	6,550	4,770	4,400	370	114	No

[1] Under the Proposed Action and other action alternatives, the North Gap Pit expansion area would be backfilled, precluding the development of a pit lake.
[2] The currently approved Crossroads and Gap pits are part of the existing Pipeline Pit.

Source: Geomega 2007f.

As previously analyzed in the Pipeline/South Pipeline Pit Expansion Project Final SEIS (BLM 2004e), post-mining pit lakes were predicted to develop in the Gap and Crossroads pits which comprise the western and southeastern portions of the Pipeline Pit, respectively (**Figure 2-9**). Under the currently proposed project, the North Gap Pit expansion area would be developed and subsequently backfilled. Although backfilling would preclude the development of a post-mining pit lake in this portion of the Pipeline Pit, the numerical modeling conducted for this analysis indicates that with the Proposed Action, the Gap Pit lake would have essentially the same surface area as previously predicted, but the lake surface elevation would be higher, and therefore, the lake would be deeper and store a larger volume of water. As expected, the modeled surface area, lake surface elevation, and depth of the Crossroads Pit lake would be essentially the same as previously predicted. Based on the numerical modeling results, it is anticipated that both the Crossroads and Gap pit lakes would behave as sinks, with no throughflow to the groundwater system (Geomega 2007f).

Impacts to Perennial Streams and Springs. As described above, mine-induced drawdown resulting from the Proposed Action is predicted to cause a reduction in groundwater levels both during the period of dewatering and for an extended period after dewatering ceases. For the purposes of discussion, the spring and seep locations are referred to throughout the remainder of this section simply as springs. The stream reaches and spring sites located in this area can be characterized as either ephemeral or perennial. Ephemeral stream reaches and spring sites flow only during or after wet periods in response to rainfall or runoff events. By definition, these surface waters are not controlled by discharge from the regional groundwater system. During the low-flow period of the year (late summer through fall), ephemeral stream reaches and spring sites typically would be dry. In contrast, perennial stream reaches and springs generally flow throughout the year. Flows observed during the wet periods, which typically extend from spring through early summer include a combination of surface runoff and groundwater discharge, whereas flows observed during the low-flow period are sustained entirely by discharge from the groundwater system. If the flow from these springs relies on the aquifer that is being dewatered, a reduction of groundwater levels from mine-induced drawdown could reduce the groundwater discharge to perennial stream reaches or springs for manganese and sulfate. As the average modeled concentrations were below the secondary standards



Source: Geomega 2007a.

Note: The Crossroads and Gap pits are the southeastern and western portions, respectively, of the currently approved Pipeline Pit (see **Figure 2-6**).

Cortez Hills
Expansion Project

Figure 3.2-15

Rate of Pit Lake Development
Under the
Proposed Action

reduce the length of perennial stream reaches, reduce spring flow, and correspondingly reduce associated riparian/wetland areas.

Potential impacts to perennial streams and springs were evaluated by: 1) identifying perennial streams and springs within the predicted drawdown area (defined by the 10-foot drawdown contour at various points in time in the future); and 2) evaluating the likely source of the water to identify waters that could be susceptible to mine-induced drawdown impacts. In addition, it was assumed that any spring observed to be flowing in most years between August and November was perennial and dependent upon groundwater discharge.

Two stream reaches with perennial flow occur within the predicted drawdown area on the eastern slope of the Shoshone Mountains approximately 5 miles north of the Pipeline Pit: Indian Creek and its tributary Feris Creek. However, as described above, the predicted drawdown in the Shoshone Mountains for the Proposed Action is essentially the same as predicted for the No Action Alternative. Therefore, the incremental increase in drawdown associated with the Proposed Action is not expected to result in impacts to Indian Creek or Feris Creek. Potential impacts to Indian Creek and Feris Creek are discussed under the No Action Alternative (Section 3.2.2.6) and cumulative impacts (Section 3.2.3).

The Proposed Action is predicted to result in additional drawdown in the vicinity of Mill Creek located in the Cortez Mountains approximately 2 miles northeast of the proposed Cortez Hills Pit. Perennial flow in this stream reach could be controlled by discharge from perched aquifers, or compartmentalized groundwater systems that are hydraulically isolated from the regional groundwater system that would be affected by drawdown. However, the interconnection between this perennial stream reach and the regional bedrock system that would be impacted by long-term, mine-induced drawdown is not well understood. Considering the uncertainty, this analysis conservatively assumed that perennial flows in Mill Creek could be interconnected to the regional bedrock groundwater system and therefore could be impacted. An additional reduction in groundwater levels potentially could further reduce flows and possibly reduce the length of the perennial stream reach. A reduction of flows in Mill Creek would be considered a significant impact. Significant impacts to other streams in the study area are not anticipated.

The model simulation results indicate that there are 50 inventoried perennial springs located within the predicted drawdown area (as defined by the 10-foot groundwater drawdown contour). These springs occur in several groups defined by geologic and geographic locations in the HSA, as described in Section 3.2.1.1. There are 28 springs located in the Horse Canyon area group that occur within the predicted drawdown area. Available information for the Horse Canyon area group suggests that these springs occur in localized perched groundwater systems that are not interconnected with the regional groundwater system. Therefore, impacts to springs within the Horse Canyon area group are not anticipated. For purposes of this analysis, it is assumed that springs located in the drawdown area and that occur in the East Valley Springs group, Toiyabe Catchment group, and other small groups located in the immediate vicinity of the Cortez Pit potentially could be impacted by the incremental increase in drawdown attributable to the Proposed Action. There are 22 inventoried springs that occur within these areas that could experience increased drawdown attributable to the Proposed Action (**Table 3.2-12**). As previously described, the predicted drawdown in the Shoshone Mountains and Rocky Pass area west and northwest of the Pipeline Pit is essentially the same as

Table 3.2-12
Perennial Surface Water Resources and Associated Wetland/Riparian Vegetation Potentially Impacted By Mine-related Groundwater Drawdown[1]

			Surface Water Resources Located in Areas Where New or Increased Drawdown Attributable to Specific Alternatives[2] Could Impact Perennial Flows			Surface Water Resources Located in Areas Where Perennial Flow Could be Impacted by Cumulative Drawdown	Associated Riparian/ Wetland Vegetation (acres)
Area	Spring Group	ID	No Action Alternative	Proposed Action[3]	Underground Alternative	Cumulative	
Cortez Hills	Mapped Cortez Spring	26-47-01-41	--	X[4]	X[4]	X[4]	0.000
	NE Toiyabe seeps	26-47-01-43	--	X[4]	X[4]	X[4]	0.000
		26-47-12-21	--	X[4]	X[4]	X[4]	0.020
	Cortez Canyon seeps and springs	27-47-36-431	X	X[4]	X[4]	X[4]	0.000
		27-47-36-433	X	X[4]	X[4]	X[4]	0.006
		26-47-01-212	X	X[4]	X[4]	X[4]	0.006
		26-47-01-214	X	X[4]	X[4]	X[4]	0.003
	NE Survey Area	27-48-30-44	X	X[4]	X[4]	X[4]	0.021
	NE Corner seeps and springs	27-48-30-421	X	X[4]	X	X[4]	0.028
		27-48-30-412	X	X[4]	X	X[4]	0.005
		27-48-30-423	X	X[4]	X[4]	X[4]	0.010
Pipeline	Rocky Pass	27-46-28-224	X[4]		--	X[4]	1.180
	Toiyabe Catchment	26-47-04-24	--	X[4]	X[4]	X[4]	0.070
		27-47-27-43	X	X[4]	X[4]	X[4]	0.000
		27-47-33-42	--	X[4]	X[4]	X[4]	0.030
		27-47-35-32	X	X[4]	X[4]	X[4]	0.690
		27-48-16-31	X	X	X	X	1.150
		27-48-19-24	--	-	X	X	0.040
	Shoshone Range	28-46-02-34	X	--	-	X	0.210
		28-46-04-33	X	--	--	X	0.460
		28-46-05-42	X	--	--	X	0.820
		28-46-15-32	X[4]	--	--	X[4]	0.040
	East Valley	28-48-28-14	--	--	X	X	0.080
		28-48-28-342	--	X	X	X	0.090
		28-48-28-343	--	X	X	X	0.040
		28-48-28-43	--	--	X	X	0.120
		28-48-32-24	X	X	X	X	0.060
		28-48-32-32	X	X	X	X	0.060
		28-48-32-33	X	X	X	X	0.080
		28-48-32-34	X	X	X	X	<0.010
		Total	**20**	**22**	**25**	**30**	**--**
Surface Water Streams	Indian Creek		X	--	--	X	
	Feris Creek		X	--	--	X	
	Cooks Creek		--	--	--	--	
	Mill Creek		X	X	X	X	
Total Acreage of Associated Wetland/Riparian Vegetation			4.829	3.49	2.609	5.319	5.319

[1] Simulated 10-foot drawdown contour reaches location of perennial surface water resource at some point in time. Excludes springs and surface water resources located in Horse Canyon that are believed to occur in localized perched groundwater systems that are not hydraulically interconnected with the regional groundwater flow system.

[2] New or increased drawdown for Proposed Action and Cortez Hills Complex Underground Mine Alternative based on comparison to drawdown predicted for No Action Alternative.

[3] Potentially affected surface water resources under the Grass Valley Heap Leach Alternative and Crescent Valley Waste Rock Alternative would be the same as under the Proposed Action.

[4] Indicates perennial surface water located in area where the groundwater levels are not predicted to fully recover within 100 years.

Source: Based on drawdown results provided in Geomega 2007f; wetland/riparian acreage from JBR 2007d.

predicted for the No Action Alternative. Therefore, the incremental increase in drawdown associated with the Proposed Action is not expected to contribute to potential impacts to springs in the Shoshone Range and Rocky Pass areas. Potential impacts to springs in the Shoshone Range and Rocky Pass area are discussed under the No Action Alternative (Section 3.2.2.6) and cumulative impacts (Section 3.2.3).

Excluding the East Valley Springs group, which appears to be connected to the basin fill aquifer in Crescent Valley (Geomega 2007e), the interconnection between springs in the other groups and the regional bedrock system that could be impacted by long-term, mine-induced drawdown is uncertain. However, for this evaluation it conservatively was assumed that all of the perennial springs located within the Toiyabe Catchment group and located in the Cortez Pit area and within the drawdown area could be interconnected to the regional bedrock groundwater system, and therefore potentially could be impacted. Potential impacts to these springs could range from reductions in flow to elimination of all flow. Groundwater levels in the vicinity of the 6 springs located in the East Valley group and for 1 spring in the Toiyabe Catchment group are predicted to eventually recover in the post-mining period (Geomega 2007f). However, 15 other springs occur within areas that are predicted to experience long-term drawdown that is not expected to fully recover within 100 years (**Table 3.2-12**). As a result, any flow reduction or elimination that occurs is likely to persist beyond this period. A reduction of flows in these springs would be considered a significant impact.

The actual impacts to individual seeps, springs, or stream reaches would depend on the source of groundwater that sustains the perennial flow (perched or hydraulically isolated aquifer versus regional groundwater system) and the actual extent of mine-induced drawdown that occurs in the area. The interconnection (or lack of interconnection) between the perennial surface waters and deeper groundwater sources is controlled in large part by the specific hydrogeologic conditions that occur at each site. Considering the complexity of the hydrogeologic conditions in the region and the inherent uncertainty in numerical modeling predictions relative to the exact areal extent of a predicted drawdown area, it is not possible to conclusively identify specific springs and seeps that would or would not be impacted by future mine-induced groundwater drawdown.

Impacts to Water Rights. For the purpose of this evaluation, all water rights owned or controlled by CGM were excluded. As shown in **Table 3.2-13**, there are 11 non-CGM owned or controlled water rights located within the predicted mine-induced drawdown area (i.e., area where the groundwater levels are predicted to be lowered by 10 feet or more resulting from the total mine dewatering activities under the Proposed Action dewatering scenario described in Section 3.2.2.1). This includes six surface water rights and five groundwater rights. According to the State Engineer's records, six of these are used for stock watering, four are used for mining and milling, and one is used for irrigation. As shown in **Table 3.2-13**, the timing and duration of the predicted drawdown varies for the different locations. Based on the modeling results, only 1 of the 11 locations is predicted to experience full recovery of water levels within 100 year after dewatering ceases.

For surface water rights, the actual impacts to individual water rights would depend on the site-specific hydrologic conditions that control surface water discharge. Only those waters sustained by discharge from the regional groundwater system would be likely to be impacted. For surface water rights that are dependent

Table 3.2-13
Estimated Water Level Change at Water Rights in Southern Part of the HSA
(Proposed Action)

Map #	Owner of Record	Years after End of Dewatering (change in feet)			
		0	25	50	100
1[1]	Connolly, Thomas	< 0.5	4	9	**18**
2	Connolly, Thomas	**14**	**45**	**66**	**87**
3[1]	Cortez Joint Venture	< 0.5	3	6	**11**
4	Connolly, Thomas	3	**18**	**29**	**38**
5	Connolly, Thomas	1	3	5	6
6	Connolly, Thomas	< 0.5	1	2	3
7	Connolly, Thomas	2	**10**	**15**	**20**
8	Connolly, Thomas	8	**36**	**59**	**83**
9	Dann, Mary	< 0.5	2	2	1
10	Dann, Mary	< 0.5	1	1	1
11	Cortez Joint Venture	**21**	**59**	**67**	**74**
12[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
13[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
14[1]	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
15	Cortez Joint Venture	< 0.5	1	1	1
16	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
17	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
18	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
19	Cortez Joint Venture	< 0.5	1	5	**17**
20[1]	Cortez Joint Venture	1	**11**	**22**	**35**
21	Cortez Joint Venture	< 0.5	3	7	**12**
22[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
23	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
24	Cortez Joint Venture	1	3	2	1
25	Mill Gulch Placer Mining Company	**27**	**56**	**47**	**43**
26	Filippini, Ed	1	**15**	**14**	**10**
27	Filippini, Ed	< 0.5	< 0.5	< 0.5	1
28	Cortez Joint Venture	1	2	2	1
29	Cortez Joint Venture	**45**	**28**	**14**	9
30	Little Gem Mining Co.	1	**17**	**12**	**10**
31	Dann, Dewey	1	2	2	1
32	Cortez Joint Venture	9	6	2	-1
33	Cortez Joint Venture	9	6	2	-1
34	Wright, Elwood	**11**	**25**	**17**	**14**
35	BLM	2	8	5	1
36	Wright, Elwood	**11**	**25**	**17**	**14**
37	Cortez Joint Venture	**18**	**111**	**147**	**174**
38	Cortez Joint Venture	**13**	**76**	**110**	**138**
39	Cortez Joint Venture	8	**48**	**74**	**96**
40	Cortez Joint Venture	**92**	**237**	**258**	**270**
41	Cortez Joint Venture	**92**	**237**	**258**	**270**
42	Cortez Joint Venture	**64**	**210**	**245**	**264**
43	Cortez Joint Venture	**64**	**210**	**245**	**264**
44	Cortez Joint Venture	**456**	**202**	**172**	**167**
45	Cortez Joint Venture	**392**	**149**	**113**	**106**
46	Cortez Joint Venture	**732**	-24	-82	-93
47	Cortez Joint Venture	**392**	**149**	**113**	**106**
48	Nevada Rae Gold Inc.	< 0.5	4	3	1
49	Nevada Rae Gold Inc.	< 0.5	4	3	1
50	Cortez Joint Venture	1	3	3	2

Table 3.2-13 (Continued)

Map #	Owner of Record	Years after End of Dewatering (change in feet)			
		0	25	50	100
51	Filippini, Henry	< 0.5	-1	< 0.5	1
52	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
53	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
54[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
55[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
56	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
57	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
58[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
59	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
60	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
61	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
62	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
63[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
64	Cortez Joint Venture	< 0.5	< 0.5	1	1
65	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
66	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
67[1]	Cortez Joint Venture	< 0.5	1	2	2
68[1]	Cortez Joint Venture	**22**	**63**	**120**	**183**
69	Cortez Joint Venture	< 0.5	1	1	1
70	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
71[1]	Tsakopoulos, Angelo K.	< 0.5	< 0.5	< 0.5	< 0.5
72[1]	Tsakopoulos, Angelo K.	< 0.5	< 0.5	< 0.5	< 0.5
73	Julian Tomera Ranches, Inc.	< 0.5	< 0.5	< 0.5	1
74	Cortez Joint Venture	**13**	2	-2	-4
75	Cortez Joint Venture	**12**	2	-2	-4
76	Cortez Joint Venture	**12**	2	-1	-3
77	Cortez Joint Venture	**11**	3	-1	-2
78	Cortez Joint Venture	**11**	3	-1	-2
79	Cortez Joint Venture	**10**	3	-1	-2
80	Wintle, Grace	**18**	**13**	3	-3
81	Cortez Joint Venture	6	3	1	< 0.5
82	Cortez Joint Venture	4	3	1	< 0.5
83	Cortez Joint Venture	9	3	< 0.5	-2
84	Connolly, Thomas	< 0.5	< 0.5	< 0.5	< 0.5
85	Cortez Joint Venture	< 0.5	< 0.5	1	2
86	Cortez Joint Venture	< 0.5	1	2	6
87	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	1
88[1]	Penola, Edna	< 0.5	< 0.5	< 0.5	< 0.5
89	Filippini Trust	< 0.5	< 0.5	< 0.5	1

Note: Bolded numbers indicate locations within the predicted 10-foot groundwater drawdown contour.

[1] Indicates a private water right located inside the HSA, but in an inactive portion of the groundwater flow model due to model grid discretization. Drawdown was evaluated at the nearest active portion of the model.

Source: Geomega 2007f.

on groundwater discharge, a potential reduction in groundwater levels could reduce or eliminate the flow available at the point of diversion for the surface water right. Impacts to wells could include a reduction in yield, increased pumping cost, or if the water level were lowered below the pump setting or the bottom of the well, make the well unusable. Specific impacts to wells would depend on the site-specific hydrogeologic conditions, well completion details, and timing of the drawdown.

The actual impacts to individual water rights would depend on the source of groundwater that sustains the water rights and the actual extent of mine-induced drawdown that occurs in the area. The interconnection (or lack of interconnection) between the water rights sources and deeper groundwater sources is controlled in large part by the specific hydrogeologic conditions that occur at each site. Considering the complexity of the hydrogeologic conditions in the region and the inherent uncertainty in numerical modeling predictions relative to the exact areal extent of a predicted drawdown area, it is not possible to conclusively identify specific water rights that would or would not be impacted by future mine-induced groundwater drawdown.

Impacts to the Regional Water Balance. The water balance for the groundwater system within the HSA was estimated using the groundwater flow model (Geomega 2007f) using the total mine dewatering and water management requirements under the Proposed Action as described in Section 3.2.2.1. The estimated annual groundwater inflow and outflow rates under the baseline condition (2004); end of dewatering; and 25, 50, and 100 years after dewatering are summarized in **Table 3.2-14**. The water balance provides an estimate of the annual change in storage and fluctuations of the major inflow and outflow components over time resulting from the mine dewatering and water management activities. Under the baseline conditions, the water balance illustrates that the annual depletion of water in storage is partially offset by infiltration recharge. The water balance estimates indicate that the mine-induced drawdown associated with mine dewatering is predicted to result in a decrease in evapotranspiration. At 100 years after dewatering ceases, the evapotranspiration rates are predicted to return to baseline conditions, and the water balance essentially would be at equilibrium conditions. The quantity of groundwater that discharges to the Humboldt River, Pine Valley, and Grass Valley is not predicted to change significantly as a result of the mine dewatering and water management activities.

Water Quality Impacts

Pit Lake Water Quality. A hydrochemical evaluation of pit lake water quality under the Proposed Action was performed by Geomega (2007a). This study evaluated the pit lake chemistry associated with the Cortez and Cortez Hills pit lakes, as well as the two pit lakes (Gap and Crossroads) previously projected for the currently permitted Pipeline Pit. The general methodology used to predict pit lake water quality is summarized in Section 3.2.2.1, Evaluation Methodology.

Modeling was conducted for the Gap, Crossroads, and Cortez Hills pit lakes under the Proposed Action. Modeling was not performed to predict the Cortez Pit lake chemistry; the projected chemistry of this pit lake was based on observations from the former Cortez Pit lake (see **Table 3.2-8**). Use of the observed pit lake water data was determined to be appropriate, because no new lithologies would be exposed in the ultimate pit surface, and no major changes would occur in pit morphology under the Proposed Action. The long-term

Table 3.2-14
Simulated Groundwater Budget for the HSA Under the Proposed Action
(acre-feet per year)

Budget Component	Baseline Conditions (2004)	End of Dewatering	25 Years after Dewatering	50 Years after Dewatering	100 Years after Dewatering
Inflow					
Precipitation Recharge	22,800	22,800	22,800	22,800	22,800
Infiltration Recharge	34,700	2,400	0	0	0
Subsurface Inflow (Rocky Pass)	300	300	300	300	300
Pit Lakes	0	700	200	0	0
Total Inflow	57,800	26,200	23,300	23,100	23,100
Outflow					
Evapotranspiration	16,300	10,700	12,800	14,900	16,600
Subsurface Outflow					
Grass Valley	1,300	1,300	1,300	1,300	1,200
Pine Valley	400	400	400	400	400
Mine Dewatering	37,600	14,200	0	0	0
Consumptive Use	2,900	2,600	2,600	2,600	2,600
Pit Lakes	0	5,200	2,100	1,300	1,100
Outflow to Humboldt River	400	400	400	400	400
Total Outflow	58,900	34,800	19,600	20,900	22,300
Inflow Minus Outflow	-1,100	-8,600	3,700	2,200	800

Source: Geomega 2007f.

(100 years) predicted pit lake water chemistry data for the Gap, Crossroads, and Cortez Hills pit lakes under the Proposed Action are summarized in **Table 3.2-15**.

The long-term pH values predicted for the three pit lakes modeled under the Proposed Action were mildly alkaline, with pH values ranging from 8.32 to 8.47. Solid phases expected to form and control aqueous concentrations in the pit lakes included calcite, otavite, gibbsite, barite, manganite, and amorphous ferric hydroxide (AFH). The Cortez Hills Pit lake water had no predicted constituent concentrations in excess of Nevada water quality standards, although the predicted arsenic concentration slightly exceeded the federal arsenic standard of 0.01 mg/L. Predicted water chemistry for the Crossroads Pit lake under the Proposed Action was similar to the Cortez Hills Pit lake, except for fluoride, sulfate, and TDS, which exceeded secondary standards. The Gap Pit lake had aluminum, sulfate, and TDS concentrations in excess of secondary standards. In addition, predicted fluoride and thallium concentrations exceeded primary standards for the Gap Pit lake. Also, the predicted antimony concentration (0.007 mg/L) for the Gap Pit lake slightly exceeded the federal primary drinking water standard (0.006 mg/L). Predicted thallium concentrations in excess of the standards are likely due to the close proximity of the analytical detection limit (0.001 mg/L) to the standard (0.002 mg/L) and use of one-half of the detection limit for numerous below detection limit analyses (Geomega 2007a). The most important controls on pit lake water chemistry appear to be the composition of the influent groundwater and the effects of evapoconcentration. Based on the model results, these processes appear to quickly overwhelm the effects of waste rock leaching and control long-term pit lake chemistry under the Proposed Action.

The results of the pit lake modeling studies at 20 years were compared to the available Cortez Pit lake data, which was collected after 20 years of infilling and evapoconcentration. This comparison indicated that the

Table 3.2-15
Model-predicted Pit Lake Water Chemistry at Year 100

Constituent (mg/L)[1]	Applicable Nevada Drinking Water Standards[2]	No Action Alternative		Proposed Action		
		Crossroads[3]	Gap[3]	Cortez Hills	Crossroads[3]	Gap[3]
Aluminum	0.05[3] – 0.2[4]	0.04	0.06	0.04	0.04	0.06
Antimony	0.146[5]	0.004	0.008	0.004	0.005	0.007
Arsenic (total)	0.05[5]	0.017	0.046	0.026	0.017	0.038
Barium	2.0	0.02	0.01	0.06	0.02	0.01
Beryllium	0.004	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	--	0.24	0.92	0.17	0.42	0.85
Cadmium	0.005	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Calcium	--	25.3	14.5	22.2	24.7	16.1
Chloride	250[3], 400[4]	54	108	46	54	101
Chromium (total)	0.1	0.009	0.016	0.005	0.009	0.014
Copper	1.3[8], 1.0[4]	0.006	0.011	0.006	0.006	0.010
Fluoride	2.0[3], 4.0[4]	3.5	7.3	0.7	3.6	6.0
Iron	0.3[3], 0.6[4]	< 0.01	< 0.010	< 0.01	< 0.01	< 0.01
Lead	0.015[8]	0.008	0.01	0.003	0.008	0.009
Magnesium	125[3], 150[4]	39.8	71.7	23.1	40.0	67.8
Manganese	0.05[3], 0.1[4]	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Mercury	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	0.1	0.024	0.029	0.008	0.024	0.027
Nitrate (as N)	10	0.8	1.5	0.8	0.8	1.4
pH (standard units)	6.5 – 8.5[4]	8.34	8.50	8.32	8.34	8.47
Potassium	--	22.8	41.9	11.6	23.3	36.9
Selenium	0.05	0.005	0.009	0.008	0.005	0.009
Silver	0.1[4]	0.007	0.014	0.004	0.007	0.012
Sodium	--	145	292	53	147	254
Sulfate	250[3], 500[4]	251	471	54	252	429
Thallium	0.002	0.001	0.003	0.001	0.002	0.003
Total Alkalinity	--	190	284	175	192	268
TDS	500[3], 1000[4]	732	1,295	387	738	1,181
Zinc	5.0[4]	0.024	0.036	0.006	0.024	0.033

1 Units are milligrams per liter (mg/L) unless otherwise noted.
2 Nevada primary MCLs unless otherwise noted. Federal primary standards of July 1, 1993, are incorporated by reference in NAC 445A.453.
3 Federal secondary MCLs.
4 Nevada secondary MCLs
5 Federal primary MCL for arsenic is 0.01 mg/L; federal primary MCL for antimony is 0.006 mg/L.
6 Value is action level for treatment technique for lead and copper.

Sources: 40 CFR 141.51; 40 CFR 143.3; Geomega 2007a; NAC 445A.119, 445A.144, 445A.453, and 445A.455.

results were very similar with the exception of slightly lower TDS in the Cortez Pit lake, probably due to lower TDS groundwater in this portion of the project area. Field-scale and bench-scale pit lake analog studies also were performed to evaluate the results of the pit lake modeling study. The results of these tests were consistent with the modeling predictions of pit lake chemistry.

Stratification of pit lakes can result in anoxic conditions at the bottom of the water column. In such cases, it may be possible for AFH to dissolve, releasing sorbed metals to the water column and affecting predictions of pit lake water quality. Hydrodynamic modeling of the Gap, Crossroads, and Cortez Hills pit lakes for the Proposed Action indicated that there would be mild stratification of the pit lakes in January and in summer through fall. However, stratification is predicted to always be followed by complete mixing of the water column. As a result, the predicted chemistry of the pit lake waters under the Proposed Action is not expected to be strongly affected by stratification, and dissolved oxygen is expected to be present throughout the water column.

In summary, modeling results for the Proposed Action pit lakes and examination of water quality data from the historic Cortez Pit lake indicated that the pit lakes are expected to contain good quality water that is reasonably similar to the background groundwater quality. Under the Proposed Action, the mature Gap and Crossroads pit lakes had predicted water chemistries that slightly exceeded some water quality standards. However, these pit lakes are predicted to be terminal pit lakes, and would serve as groundwater sinks. The projected Cortez Hills Pit lake water quality did not exceed any water quality standards and is expected to have a steady-state flow-through of approximately 250 gpm. As a result, it is anticipated that the formation of these pit lakes under the Proposed Action would not affect the water quality of downgradient aquifers. The expected Cortez Pit lake water quality also did not exceed water quality standards and is predicted to behave as a groundwater sink with no groundwater outflow. Therefore, the Cortez Pit lake is not expected to affect the water quality of downgradient aquifers.

Other Cortez Hills Pit Lake Scenarios. As discussed in Section 3.1.2.1, preliminary geotechnical data suggest there would be a potential for deep-seated failures to occur in the east wall of the proposed Cortez Hills Pit in the post-closure period. The area susceptible to failure consists of weak bedrock material associated with the Cortez Fault zone that would be intercepted by the east wall of the pit.

Geomega (2007i) evaluated the potential changes in pit water quality that would occur as a result of a slope failure in the east side of the pit. In summary, the evaluation indicates that the pit wall rock that would be exposed in the potential failure zone is geochemically similar to the other pit wall rock types that previously were characterized for the proposed Cortez Hills Pit lake. A bedrock failure into the pit would expose an increased volume of rock to oxidation in the pit walls and increase the leaching potential of the rock. Because the rock in the pit walls has a relatively low sulfide content and is non-acid-generating, an increase in the volume of oxidized rock exposed in the pit wall (e.g., from landslides) is not expected to result in potentially significant (relative difference of greater than 10 percent) changes in predicted pit lake chemistry. Therefore, the predicted pit lake chemistry is expected to be essentially the same as described for the proposed Cortez Hills Pit lake (Geomega 2007i)

Geomega also evaluated potential changes in pit water quality resulting from reducing the ultimate depth of the pit and flattening the pit slope in the east wall to mitigate the potential for long-term instability (Geomega 2007i). Specifically, the hydraulic response and pit water quality at 100 years were evaluated for a shallow (4,600-foot amsl ultimate floor elevation) pit and intermediate depth (4,200-foot amsl ultimate floor elevation) pit and then compared to the Proposed Action (3,800-foot amsl ultimate floor elevation) pit lake.

The results indicate that the pit lake water quality for the shallower pit (4,600-foot amsl elevation) is predicted to have higher overall constituent concentrations compared to the Proposed Action. The increased constituent concentrations for the shallower pit lake reflect the fact that evapoconcentration is higher for a smaller volume pit lake, and the pit is predicted to behave as a sink with no outflow. Although the shallow pit lake is predicted to have higher overall constituent concentrations than the proposed Cortez Hills Pit lake, arsenic (at 0.059 mg/L) is the only constituent that is predicted to exceed the Nevada drinking water standards (0.05 mg/L) (Geomega 2007i). However, this scenario is not expected to result in significant impacts to water quality since the pit lake water is not planned to be used as a drinking water source and would not discharge to groundwater.

The pit lake water quality for the intermediate depth pit (4,200-foot amsl elevation) is predicted to be similar to the Proposed Action pit lake. In addition, as with the deeper proposed Cortez Hills Pit, the intermediate depth pit would have a flow-through component (Geomega 2007i). Therefore, potential impacts associated with the intermediate depth pit would be similar to the proposed Cortez Hills Pit lake.

Waste Rock Facilities. Characterization of the waste rock and waste rock leachate chemistry for the Proposed Action were described in Section 3.2.1.4, Waste Rock Characterization. Potential impacts to groundwater resources associated with the proposed waste rock facilities at the Cortez Hills Complex were quantitatively evaluated, using modeling of variably saturated flow and transport through the waste rock facilities and the underlying vadose zone (Geomega 2007c). The anticipated effects of the Cortez and Pipeline waste rock facility expansions on groundwater at the site were qualitatively assessed (Geomega 2007c).

Cortez and Cortez Hills Complexes. The potential impacts of waste rock seepage from the proposed Canyon, North, and South waste rock facilities at the Cortez Hills Complex and Cortez Waste Rock Facility expansion area at the Cortez Complex were assessed by determining the potential locations and magnitude of waste rock seepage from the facilities; the travel time of water through the facilities; and travel time, composition, and flux of seepage that could reach underlying groundwater.

Two different ranges of depth to groundwater occur in the Cortez Hills area. The vadose zone thickness is approximately 30 to 100 feet between the Crescent Valley alluvial aquifer and the proposed Canyon Waste Rock Facility that would be constructed on the Crescent Fault hanging wall. The proposed North and South waste rock facilities and the majority of the Canyon Waste Rock Facility would be constructed on the Crescent Fault foot wall; the vadose zone beneath these proposed facility locations consists of approximately 195 to 985 feet of limestone that is in some areas overlain by alluvium. Due to the greater thickness of the vadose zone under the facilities that would be constructed on the footwall and the low rates of unsaturated flow expected in the fractured limestone, transport times to groundwater resources are expected to be much shorter for facilities constructed on the Crescent Fault hanging wall (i.e., the toe of the Canyon Waste Rock Facility). As a result, modeling was performed to evaluate flow to groundwater through the toe of the Canyon Waste Rock Facility and flow through the South Waste Rock Facility. Flow to groundwater through the North Waste Rock Facility and the majority of the Canyon Waste Rock Facility would have longer travel times than those modeled for the Canyon toe; as a result, flow from the North and Canyon waste rock facilities conservatively was assumed to be similar to the flow through the toe of the Canyon Waste Rock Facility. Modeling of flow through the toe of the Canyon Waste Rock Facility was performed in two dimensions. Flow through the South Waste Rock Facility was simulated using one-dimensional modeling because lateral flow was found to be negligible in the toe of the Canyon Waste Rock Facility. Modeling was conducted using the codes HYDRUS-1D and HYDRUS 2-D (Simunek et al. 2005).

Flow in the Canyon Waste Rock Facility was estimated to be essentially vertical. Dump thickness had the strongest influence on modeled travel time. At the toe, where waste rock thickness would be 60 feet, travel time was approximately 1,400 days, whereas travel time in areas with a thickness of 300 feet was nearly 11,000 days. Modeled travel time for water to reach the underlying shallow aquifer was approximately 2,400 days near the toe, and approximately 14,000 days near the Crescent Fault. Because of the greater travel distances to groundwater under the footwall block, travel times from the portion of the Canyon Waste Rock Facility on the footwall block would be longer than travel times predicted for the toe of the facility that overlies the hanging wall block

Flow and travel times through the North Waste Rock Facility were predicted to be similar to those for the Canyon Waste Rock Facility due to similarities in their anticipated composition, proposed construction, and elevation. As a result, travel times for water through the North Waste Rock Facility are anticipated to range from approximately 1,400 days to 11,000 days or more, depending on thickness. However, the travel time to the water table is expected to be substantially longer, because the underlying vadose zone consists of hundreds to thousands of feet of limestone rock.

Flow through the South Waste Rock Facility would be more likely than flow through the Canyon Waste Rock Facility due to the typically greater precipitation at the higher elevation of the South Waste Rock Facility. Water travel time in the toe simulation was estimated to be 4 years through 62 feet of waste rock. Travel time in the facility center simulation (500-foot thickness) exceeded the 64-year simulation period.

The potential impacts of solute transport in the waste rock seepage as it moves through the vadose zone were evaluated using an aqueous geochemistry model (PHREEQC) to simulate the effects of geochemical processes along the transport path. The results of the HYDRUS 1D vadose-zone flow modeling were linked to the geochemical model. The geochemical analysis focused on areas near the toe of the Canyon Waste Rock Facility due to the relatively short travel times to the underlying alluvial aquifer.

Solute loading from the waste rock was incorporated into the flow and transport model using site-specific, empirically derived chemical release functions. These functions were developed based on humidity cell tests and column leaching analyses described in Section 3.2.1.4, Waste Rock Characterization. Equilibrium phases in the geochemical model included iron, aluminum, and manganese oxide/oxyhydroxides (ferrihydrite, gibbsite, and pyrolusite), calcite, gypsum, and mercuric carbonate. The potential attenuation of waste rock seepage constituents (arsenic and antimony) by the alluvial soil was assessed using batch tests on soils from the site. The initial composition of the water in each model cell was set equal to the background water composition. In each time step, the flow and geochemical models were repeated to determine water and solute fluxes through the waste rock, from the bottom of the facilities and through the underlying vadose zone to the groundwater.

The volume and composition of water within the waste rock facilities, and of effluent migrating through the vadose zone from the toe of the facilities, was simulated for a period of 50 years. The predicted range of compositions for vadose-zone waste rock seepage reaching the groundwater table is summarized in **Table 3.2-16**. Maximum concentrations in the predicted seepage chemistry exceeded secondary standards for manganese and sulfate. As the average modeled concentrations were below the secondary standards and the volume of leachate is predicted to be low, impacts to groundwater from waste rock seepage are anticipated to be negligible.

Solute transport modeling indicated that arsenic and antimony concentrations in the vadose zone water at the water table beneath the Canyon Waste Rock Facility did not exceed Nevada water quality standards

Table 3.2-16
Modeled Composition of Waste Rock Seepage Reaching the Groundwater Table

Constituent (mg/L)[1]	Applicable Nevada Drinking Water Standards[2]	Minimum	Maximum	Average
Aluminum	0.05[3] – 0.2[4]	0.005	0.026	0.009
Antimony	0.146[5]	< 0.0001	0.0013	0.0004
Arsenic (total)	0.05[5]	< 0.001	0.003	0.001
Barium	2.0	0.002	0.130	0.060
Beryllium	0.004	< 0.001	0.0018	0.001
Boron	--	0.03	0.19	0.10
Cadmium	0.005	0.001	0.002	0.001
Calcium	--	6.1	131.1	57.4
Chloride	250[3], 400[4]	0.2	37.1	16.6
Chromium (total)	0.1	0.004	0.005	0.004
Copper	1.3[6], 1.0[4]	0.001	0.019	0.007
Fluoride	2.0[3], 4.0[4]	0.08	1.88	0.72
Iron	0.3[3], 0.6[4]	0.003	0.062	0.002
Lead	0.015[6]	< 0.001	0.004	0.002
Magnesium	125[3], 150[4]	0.2	34.3	15.1
Manganese	0.05[3], 0.1[4]	< 0.001	0.126	0.008
Mercury	0.002	0.0001	0.0015	0.0005
Nickel	0.1	0.005	0.021	0.010
Nitrate (as N)	10	0.2	1.5	0.6
pH (standard units)	6.5 – 8.5[4]	7.3	8.4	7.5
Potassium	--	0.8	21.8	8.8
Selenium	0.05	0.005	0.013	0.010
Silver	0.1[4]	0.003	0.023	0.010
Sodium		0.04	61.50	24.71
Sulfate	250[3], 500[4]	8	343	150
Thallium	0.002	0.001	0.002	0.001
Total Alkalinity	--	17	417	21
Zinc	5.0[4]	0.001	0.010	0.007

1 Units are milligrams per liter (mg/L) unless otherwise noted.
2 Nevada primary MCLs unless otherwise noted. Federal primary standards of July 1, 1993, are incorporated by reference in NAC 445A.453.
3 Federal secondary MCLs.
4 Nevada secondary MCLs
5 Federal primary MCL for arsenic is 0.01 mg/L; federal primary MCL for antimony is 0.006 mg/L.
6 Value is action level for treatment technique for lead and copper.

Sources: 40 CFR 141.51; 40 CFR 143.3; Geomega 2007c; NAC 445A.119, 445A.144, 445A.453, and 445A.455.

during the 50-year simulation period. Leachate leaving the bottom of the facility exceeded the applicable Nevada water quality standards of 0.05 mg/L for arsenic and 0.146 mg/L for antimony during part of the simulation period. However, attenuation reduced these concentrations substantially before the vadose zone water reached the water table. Predicted concentrations in vadose zone water approaching the water table for these two constituents were relatively constant at the end of the 50-year simulation period, indicating that applicable water quality standards would not be exceeded in the future because of leachate from the waste rock facility.

No impacts to groundwater are anticipated as a result of the Cortez Waste Rock Facility expansion. Leachate from the expanded facility is expected to meet all applicable Nevada water quality standards, based on observed water quality in the former Cortez Pit lake. This pit lake water was equilibrated with the pit wall rock and should provide a reasonable estimate of waste rock leachate water quality (Geomega 2007c).

Pipeline Complex. Construction of the proposed Pipeline Waste Rock Facility expansion area would be similar to the previously approved construction for the existing facility, with the exception of the extent of the disturbance area (**Table 2-1)**. Depth to groundwater would remain unchanged at approximately 340 feet. The composition of the waste rock that would be added to the facility under the Proposed Action does not differ substantially in whole-rock chemistry or leachate composition from the waste rock included in the previously approved design (Section 3.2.1.4, Waste Rock Characterization). The facility would be constructed in terraces by end-dumping, regraded to an approved slope, covered with growth media, and revegetated as described in Section 2.4, Proposed Action. The hydraulic properties of the expanded facility should be comparable to those found in the existing facility because the same construction methods and terrace heights would be used, the waste rock would be similar, and the final depth of the facility would be relatively unchanged. Based on previous studies of potential seepage formation in the approved waste rock facility (BLM 2004e), infiltration is unlikely to move below the upper 4 feet of the waste rock pile, effectively preventing the formation of seepage that could affect underlying groundwater resources.

Heap Leach Facilities. As described in Section 3.2.1.4, Waste Rock Characterization, leachate from the existing and proposed heap leach facilities is likely to have concentrations of antimony, cadmium, and nitrate that would exceed their respective Nevada drinking water standards. The design of the heap leach facilities is described in Section 2.4.6.1, Heap Leach Facilities. Under the Proposed Action, the facility would be designed in accordance with standard geotechnical design practices; would include a composite liner and leak detection system; and would be designed, constructed, operated, and closed in accordance with NDEP requirements. Therefore, significant impacts to surface and groundwater quality from these facilities are not anticipated.

As described in Section 2.4.12.6, Reclamation, a Final Plan for Permanent Closure detailing draindown solution management (or alternate methodology), management requirements for any long-term effluent discharge, and closure would be developed 2 years prior to project closure in accordance with NDEP requirements (NAC 445A.446 and 445A.447). Geochemical investigations of ore from the Pipeline deposit (which is similar in nature to the Cortez Hills deposit) and subsequent geochemical modeling were conducted by SRK (2004). Based on this information, recirculation or rinsing of the heaps would provide no additional benefit to their long-term chemical stability. Closure projects conducted at the Cortez Gold Mines Operations Area with similar ore indicate that cyanide concentrations from closed process facilities range between below method detection limit (0.01 mg/l) to 0.15 mg/l (CGM 2007e). The operational similarities between the proposed facilities and recently closed facilities suggest that future cyanide concentrations also would be in that range. Following the completion of leaching, the heaps would be allowed to drain. It is anticipated that under normal weather conditions, approximately 2 years would be required for draindown. During closure of the heap leach facilities, all fluids would be contained in zero discharge facility components. Fluids would be managed using evaporation cells, evapotranspiration cells, or other approved methods as described in Section 2.4.12.6, Facility Reclamation.

Tailings Facilities. Under the Proposed Action, the existing tailings facility associated with the Cortez Mill would be expanded. A preliminary design for this proposed facility is not available. However, the plan of operations indicates that the design of the facility would be similar to the existing tailings area (TA 7) and include a basal composite liner consisting of two 6-inch lifts of low permeability soil overlain by a layer of 60-mil HDPE geomembrane material. Leak detection for the facility would be installed for the impoundment, the solution collection channel, and the underdrain pond. Additional details of the tailings facility design are presented in Section 2.4.6.3, Tailings Facilities.

The tailings facility would be constructed on unconsolidated basin fill alluvial material. The alluvium consists of discontinuous lenses of fine-grained soil within predominantly sandy sediments. The depth to groundwater in the vicinity is estimated to be approximately 60 feet. The groundwater in the basin fill is unconfined and generally flows toward the northwest.

Tailings facilities are not anticipated to have a significant impact to surface or groundwater quality because the facilities would be designed in accordance with standard geotechnical design practices; would include a composite liner and leak detection system; and would be designed, constructed, operated, and closed to contain process fluids and prevent discharge in accordance with NAC 445A.437, 445A.437, and 445A.438.

As described in Section 2.4.12.6, Reclamation, a Final Plan for Permanent Closure detailing management requirements for any long-term effluent discharge and closure would be developed 2 years prior to project closure in accordance with NDEP requirements (NAC 445A.446 and 445A.447). The final configuration of the proposed tailings expansion area would be designed to maximize runoff and minimize infiltration of direct precipitation and provide for long-term containment of the tailings.

Infiltration Basins. Under the Proposed Action, the dewatering rates would be less than 5 percent higher than those of the No Action Alternative for the first 3 years, reaching a maximum of 14.7 percent higher in 2012. This incremental increase should not add substantially to the volume of the groundwater mound. The Proposed Action would thus have essentially the same effect on groundwater salinity as the No Action Alternative (i.e., currently permitted activities) (Section 3.2.2.4).

Erosion, Flooding, and Sedimentation

The major potential impacts to surface water resources as a result of the Proposed Action would involve: 1) increased flooding potential due to the location of components with respect to FEMA-designated floodplains, 2) the potential for channel scour and sedimentation as a result of rerouted drainage pathways, 3) the removal of existing channels and contributing watershed areas as a result of component placement and stormwater controls, and 4) degradation of surface water quality as a result of mining effects on the chemistry of runoff or baseflow.

The potential direct impacts to surface water resources resulting from proposed pits, waste rock facilities, and heap leach facilities are discussed above. In general, potential impacts on surface water quantity and quality would be avoided, minimized, or mitigated through compliance with state and federal regulatory programs and by CGM's committed environmental protection measures (see Section 2.4.11, Applicant-committed Environmental Protection Measures). Waste rock leachates had mildly alkaline pH, with low TDS and metals concentrations. Given these characteristics and the essentially negligible lateral flow components indicated from waste rock facility modeling, significant impacts on surface water from waste rock seepage are not anticipated. Potential releases to receiving waters from heap leach facilities or other project components would be minimized by compliance with water pollution control measures, and by the project setting in closed basins with highly permeable alluvial fans.

The FEMA-designated floodplain through the study area is shown in **Figure 3.2-4**. Proposed project components that intersect the delineated floodplain include:

- Pipeline Waste Rock Facility expansion (in Sections 16, 17, and 18, T27N, R47E)
- Relocated CR 225 (in Sections 15, 16, 17, and 18, T27N, R47E)

The proposed placement of these components would encroach upon the cross-sectional area of the flow under the 100-year flood event. As a result, flooding may occur outside the current delineated floodplain, which likely would result in erosion of soils and sediments on the south side of the current flood zone. Flood flow also would impinge on the relocated road and the south toe of the Pipeline Waste Rock Facility expansion area, and may damage these features. Depending on the modified flow path, a substantial amount of water and sediment could flow outside the current floodplain delineation. To the northeast of the Cortez access road (downstream of Sections 11 and 12, T27N, R47E), the flood flows would be likely to return to the area delineated as the existing floodplain. Although the flow pathway would be affected, increases in overall flood discharge or the incidence of flooding are not anticipated to be significant. This is due to the relatively small proposed project area in comparison to the overall watershed area that contributes to flow. However, flow velocities, floodwater depths, erosion and sediment transport, and related flood hazards would be increased in the areas where channel constrictions and obstructions would occur. Erosion and sedimentation impacts would occur in overland areas downstream until the point where flows returned to the pre-disturbance floodplain. In these areas downstream of the project, flood damages and the threat to property and public safety would be minimal due to the sparseness of structures and improvements, and the enclosed nature of the drainage system.

Potential water quality impacts also would occur from floodplain encroachment. Potential impacts would be caused by additional suspended sediments and turbidity, as well as from flows coming into direct contact with waste rock materials and road residues. Due to the potential for these flow and water quality impacts, additional mitigation is recommended.

Diversions and stormwater detention features would be designed and constructed in accordance with NDEP guidelines based on the 10-, 25-, or 100-year flood events, as appropriate. Runoff routed into a drainage from an additional contributing watershed area would be likely to create or accelerate scour and sedimentation in the receiving drainage. Intermittent or ephemeral drainages where this would be most likely to occur are in the southeastern part of the study area, downgradient of the proposed Canyon and South waste rock facilities, CR 222 relocation, and Grass Valley Heap Leach Facility. Stormwater diversions in the area of the proposed Cortez Hills Pit and Canyon Waste Rock Facility would be routed through lined and unlined collection ditches and secondary ditches, as described under the Proposed Canyon Waste Rock Facility subheading in Section 2.4.5, Waste Rock Facilities. There would be minimal potential for water quality impacts to runoff from the proposed ditch configuration and lining across the Canyon Waste Rock Facility. The collected stormwater flows would be routed down a steep hillslope to the existing stream channel in Copper Canyon. The contributing watershed area would be several times the area of the existing drainage, increasing the magnitude and duration of storm event flows in lower Copper Canyon. As a result, channel and bank erosion are likely to occur over approximately 1 mile of the downstream section of the canyon immediately above where it exits the mountain front and disperses onto the alluvial fan. Based on the relatively short stream reach, bedrock controls in the canyon, general lack of surface water resources, and nearby depositional environment on permeable alluvial fan surfaces, erosion and sedimentation from stormwater diversion in this area would not be significant.

BMPs to control runoff, erosion, and sedimentation would be implemented and maintained on new drainage features as part of permit approval and compliance. In addition, the extent of impacts from routing more runoff into existing channels or onto the alluvial fans would be limited, since such flows would rapidly seep into the alluvial fan sediments.

During the life of the project and subsequent reclamation activities, the proposed stormwater diversion east of the Cortez Hills Pit would be inspected and maintained in compliance with permit requirements. After reclamation, however, the proper function of this diversion would depend on its final design capacity, its long-term integrity, and the long-term performance of outlet collection or dispersal structures.

Overtopping or seepage through the bed and sides of the diversion would contribute moisture to the east wall of the Cortez Hills Pit. As discussed in Section 3.1.2.1, Pit Slopes, long-term stability concerns exist in this locale. If stormwater infiltration along the diversion reached sufficient depths and volumes, it would reduce pit wall stability and may contribute to mass failure. Failure of diversion outlet features to properly reduce stormwater velocities would accelerate erosion and sedimentation, creating long-term instabilities in drainages receiving routed stormwater.

The proposed relocation of CR 222 and the placement of the proposed Canyon Waste Rock Facility would remove approximately 0.5 mile of an existing unnamed intermittent creek and associated streamside vegetation. Intermittent pools occur in this stream reach, and their removal would be an adverse impact on surface water resources. Otherwise, the placement and operation of proposed project components would be unlikely to create noticeable effects on overall watershed yield.

3.2.2.3 Grass Valley Heap Leach Facility Alternative

Under this alternative, the Grass Valley Heap Leach Facility would be moved approximately 1.5 miles to the southeast of the proposed location (**Figure 2-14**). All other facilities would be the same as for the Proposed Action.

The location of the Grass Valley Heap Leach Alternative is relatively flat and slopes downward to the southwest at a slope between 4 and 14 percent. The surface, subsurface, and groundwater conditions beneath the site are similar to conditions for the Proposed Action. Therefore, potential impacts to groundwater quantity and quality are anticipated to be similar to the Proposed Action.

There are no perennial surface water bodies in the vicinity of the proposed or alternative heap leach pad locations. The only surface water in the area is ephemeral and results from intermittent flows from stormwater runoff and snowmelt. Depth to groundwater beneath the alternative heap leach location is estimated to be between 300 and 600 feet below ground surface. Potential impacts on surface water under the Grass Valley Heap Leach Facility Alternative would be similar in nature, location, and extent to those described for the Proposed Action.

3.2.2.4 Crescent Valley Waste Rock Alternative

Under this alternative, the Crescent Valley Waste Rock Facility would be constructed on the valley floor; the Canyon Waste Rock Facility would not be constructed (**Figure 2-16**).

Water Quantity Impacts

Under this alternative, state and federal regulatory requirements, permit approval processes, and CGM's committed environmental protection measures would be similar to those for the Proposed Action. Potential impacts to perennial streams and other surface water resources would be similar in nature and extent to those described for the Proposed Action. However, the infilling of intermittent and ephemeral streams in the Cortez Canyon and lower Copper Canyon drainages would not occur under this alternative since the Canyon Waste Rock Facility would not be constructed.

Water Quality Impacts

The Crescent Valley Waste Rock Facility would be underlain by alluvial sediments, and would be located on the hanging wall of the Crescent Valley Fault. The depth to groundwater underneath the Crescent Valley Waste Rock Facility would be approximately 25 to 50 feet, similar to depth to groundwater beneath the toe of the Canyon Waste Rock Facility.

Flow and transport modeling through the Crescent Valley Waste Rock Facility was described by Geomega (2007c). Flow modeling was carried out using the HYDRUS-1D code (Simunek et al. 2005) and transport modeling was performed using PHREEQC, as previously described for the Proposed Action. One-dimensional unsaturated flow was simulated for the Crescent Valley Waste Rock Facility because two-dimensional flow modeling for the Canyon Waste Rock Facility toe indicated that lateral flow was minimal. Water travel time in the toe of the facility was estimated to be approximately 5.5 years through the waste rock and about 7 years to the water table. Results for the center of the facility indicated that water travel time exceeded the 64-year simulation period, and the flux rate at the bottom of the facility was essentially zero throughout the simulation period. In simulations carried out with an intermediate dump thickness, the water travel time through the waste rock facility was approximately 40 years and approximately 43 years to the water table.

Solute transport modeling indicated that arsenic and antimony concentrations in the vadose zone water at the water table beneath the Crescent Valley Waste Rock Facility did not exceed Nevada water quality standards during the 55-year simulation period. Leachate leaving the bottom of the facility exceeded the applicable Nevada water quality standards of 0.050 mg/L for arsenic and 0.146 mg/L for antimony during part of the simulation period. However, attenuation reduced these concentrations substantially before the vadose zone water reached the water table. Predicted concentrations in vadose zone water approaching the water table for these two constituents were relatively constant at the end of the 55-year simulation period, indicating that under this alternative, applicable water quality standards would not be exceeded as a result of leachate from this waste rock facility.

Erosion, Sedimentation, and Flooding

Under this alternative, the development of the Crescent Valley Waste Rock Facility would further obstruct the floodplain in Crescent Valley, well beyond that described for the Proposed Action. Construction of the alternative waste rock facility and the alternate rerouting of the county road would almost completely obstruct the existing floodplain area in Sections 9, 10, 15, and 16, T27N, R47E. Although drainage requirements could be met for normal conditions, it is likely that the reduced channel conveyance would pool flood flow in Sections 16 and 17, T27N, R47E.

Large floods are uncommon and have relatively short durations in Nevada. However, such extreme events have occurred in many parts of the state, and may occur elsewhere. Under this project alternative, flood flows between the proposed Pipeline Waste Rock Facility expansion and the proposed Crescent Valley Waste Rock Facility would have much greater depths and velocities than either the pre-existing condition or the Proposed Action. This would create temporarily hazardous conditions for human life and property both upstream and downstream of the floodplain obstruction. In addition, the toes and sideslopes of both waste rock facilities would be eroded and the sediments carried downgradient. The overall scour depth and width of the constricted flood conveyance are unknown. Modified flow conditions also would erode existing channel materials. Transported sediment, including waste rock, would be deposited downstream in Crescent Valley. The extent of scour and deposition are unknown, but are likely to be limited to within 1 or 2 miles of the proposed conveyor corridor (see **Figure 2-16**). Hazardous conditions and significant flood damages further downstream in Crescent Valley are unlikely due to the sparseness of development and the depositional topography of the closed basin.

3.2.2.5 Cortez Hills Complex Underground Mine Alternative

Under this alternative, surface facilities (including the proposed Cortez Hill Pit) would not be constructed at the Cortez Hills Complex. Surface facilities associated with the underground operation would be developed in areas of existing disturbance at the Cortez Complex (**Figure 2-18**).

Water Quantity Impacts

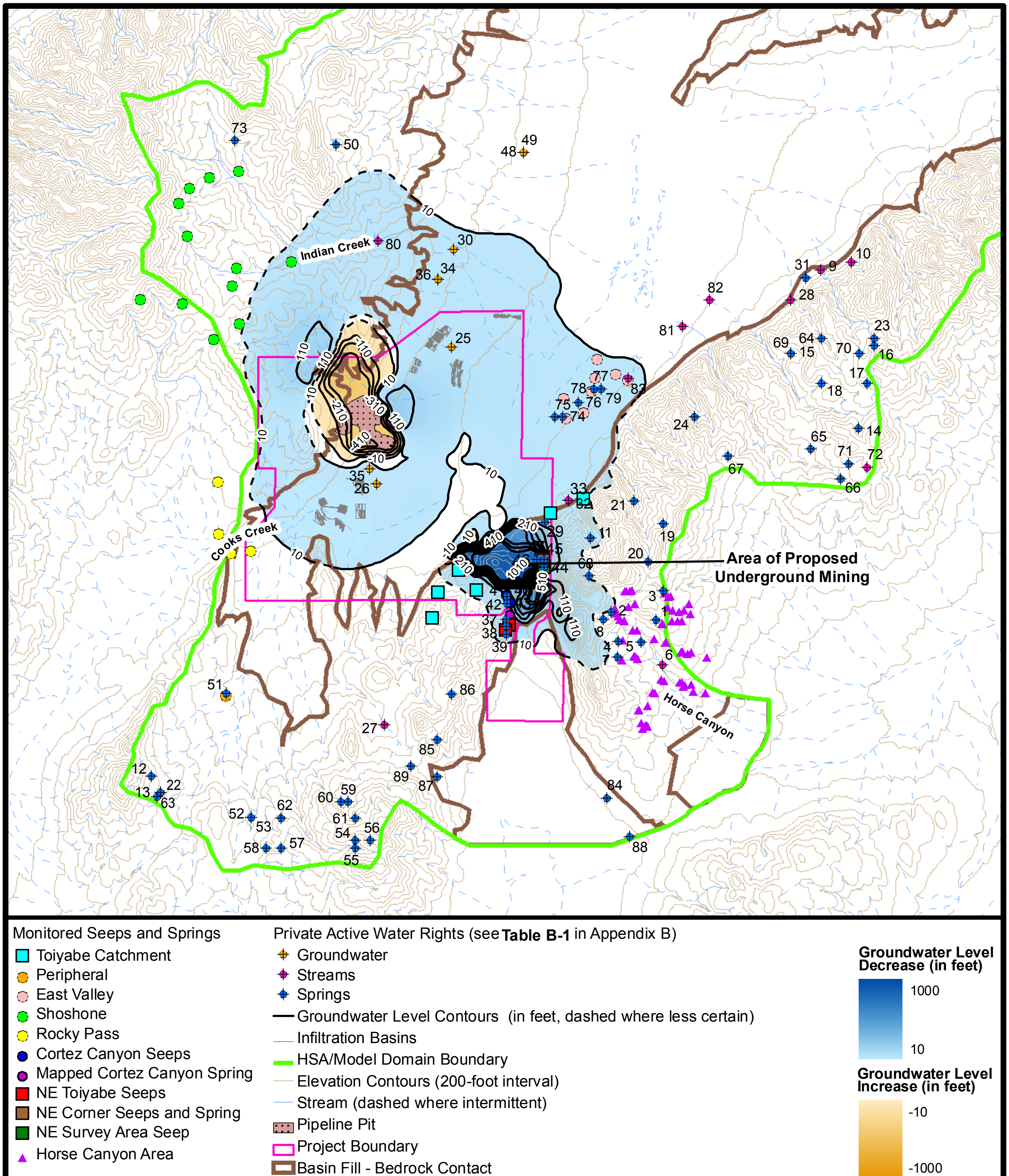
Dewatering and Water Management Activities. The dewatering scenario modeled for the underground mine alternative represents the total dewatering requirements for all previously authorized and projected future activities at the existing Pipeline Pit and Cortez Hills Underground Exploration Project and additional dewatering requirements for the underground mining operation. The final target dewatering elevation in the underground operation is 3,800 feet (1,600 feet of drawdown), which is the same as the Proposed Action. No change in the currently authorized final target dewatering elevation for the Pipeline Pit would occur under this alternative. The estimated dewatering and infiltration rates and duration of dewatering that would be required under this alternative are provided in **Table 3.2-9**. As shown in **Figure 3.2-10**, the dewatering requirements for the underground mine alternative would be similar to the Proposed Action. However, the dewatering scenario analyzed for the numerical groundwater flow model indicates that the underground mine alternative would extend the period of dewatering an additional 8 years (Geomega 2007d) as described in Section 3.2.2.1. (It is important to note that the actual startup dates for the Cortez Hills Complex Underground Mine Alternative would depend on authorizations from the BLM and permits from other state and federal agencies. Current estimates assume that dewatering operations for this alternative would start in 2008, and dewatering would continue for approximately 16 years (see Section 2.5.1.4, Cortez Hills Complex Underground Mine Alternative).

Impacts to Water Levels. The dewatering scenario for the Cortez Hills Underground Mine Alternative, and methodology for the impact evaluation are described in Section 3.2.2.1, Evaluation Methodology. The predicted change in groundwater levels under this alternative at the end of dewatering, 25 years after dewatering, and 100 years after dewatering are provided in **Figures 3.2-16**, **3.2-17**, and **3.2-18**, respectively. These figures illustrate areas where the water levels are predicted to decrease or increase over time in comparison to the baseline groundwater elevations at the end of 2004. The general timing and areal extent of the drawdown would be similar to drawdown predicted for the Proposed Action.

At the end of dewatering, two distinct drawdown areas would develop: one centered on the Pipeline Complex and one centered on the Cortez Complex. In the vicinity of the underground operation, comparison of the three periods indicates that the maximum extent of the 10-foot drawdown contour is predicted to expand in the post-mining period and would reach or would approach a maximum extent in most areas by approximately 100 years after dewatering (Geomega 2007d). The maximum area of drawdown (defined by the 10-foot contour) is predicted to extend beneath the Cortez Mountains into the Pine Valley Hydrographic Area, and into the northern portion of Grass Valley Hydrographic Area. In addition, the hydrologic divide between Crescent Valley and Grass Valley is predicted to shift slightly (less than 0.5 mile) south compared to the baseline conditions (Geomega 2007d).

In Crescent Valley, at the end of dewatering, the drawdown in the basin fill aquifer is predicted to extend across to the eastern side of the valley. In the post-dewatering period, the water levels would recover on the eastern side of the valley, but the drawdown area would expand toward the northwest beneath the Shoshone Range in the vicinity of Indian Creek. As described for the Proposed Action, the drawdown in Crescent Valley in areas located south and northeast of the Pipeline Complex are an artifact of the baseline conditions used for the analysis (Geomega 2007f). Prior to December 2004, the water levels in these areas had increased due to mine infiltration activities. After infiltration activities cease, the groundwater mounds would dissipate, and water levels would decline to pre-mining conditions. Therefore, the apparent drawdown in these two areas results from dissipation of the groundwater mounds from prior infiltration activities and not from mine-induced drawdown.

The incremental changes in groundwater levels attributable to the Cortez Hills Complex Underground Mine Alternative were evaluated by comparison to the model simulated water level changes for the No Action Alternative described in Section 3.2.2.6. The comparison at the various time intervals indicates that the drawdown predicted to occur beneath the Shoshone Range west and northwest of the Pipeline Pit and in the Crescent Valley area north, west, and south of the Pipeline Pit, essentially would be the same as predicted for the No Action Alternative. Therefore, the incremental increase in dewatering under the Underground Mine Alternative is not predicted to substantially affect water levels in areas already projected



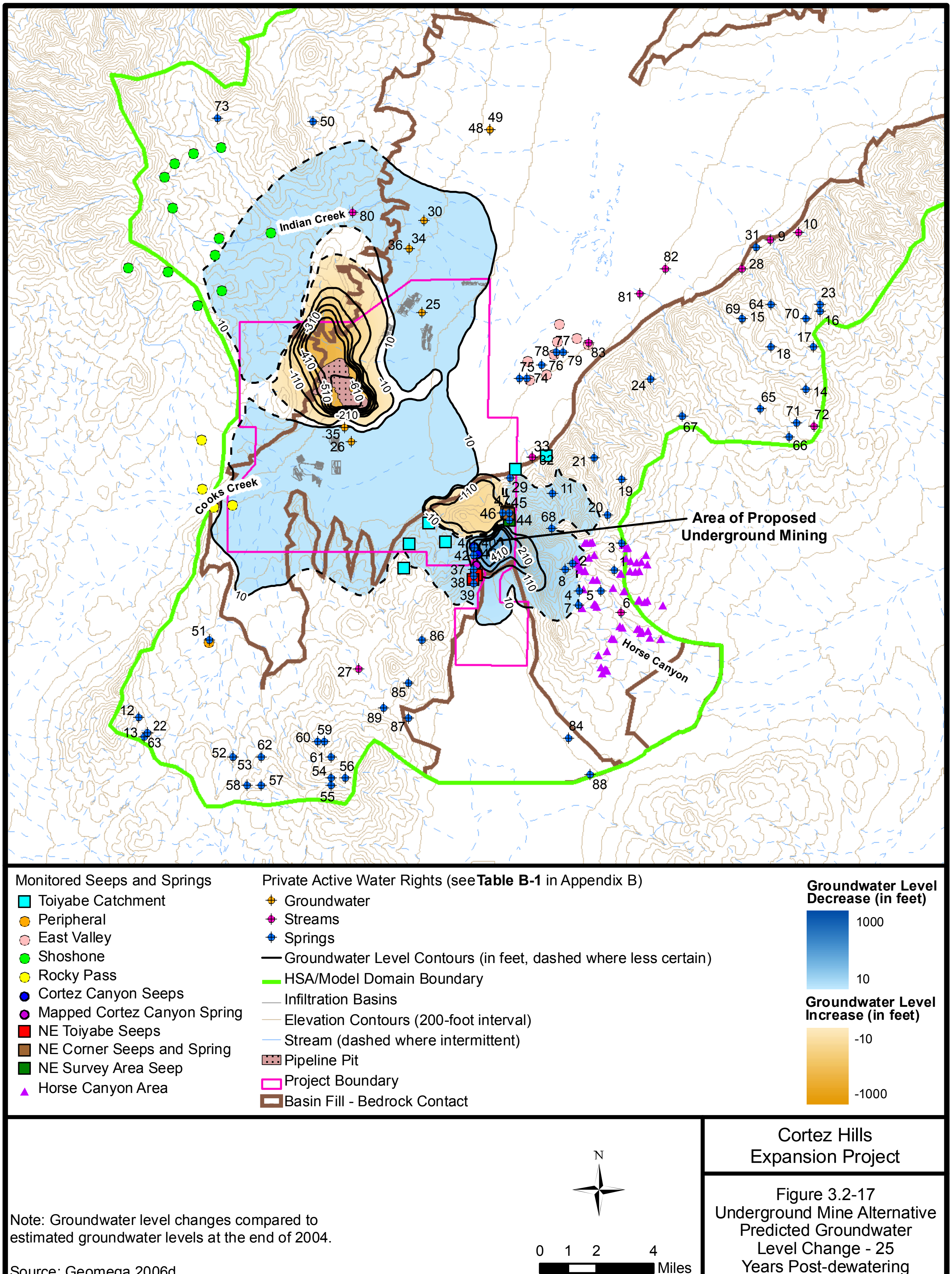
Note: Groundwater level changes compared to estimated groundwater levels at the end of 2004.

Source: Geomega 2006d.

Cortez Hills Expansion Project

Figure 3.2-16
Underground Mine Alternative Predicted Groundwater Level Change - End of Dewatering

06/20/2007



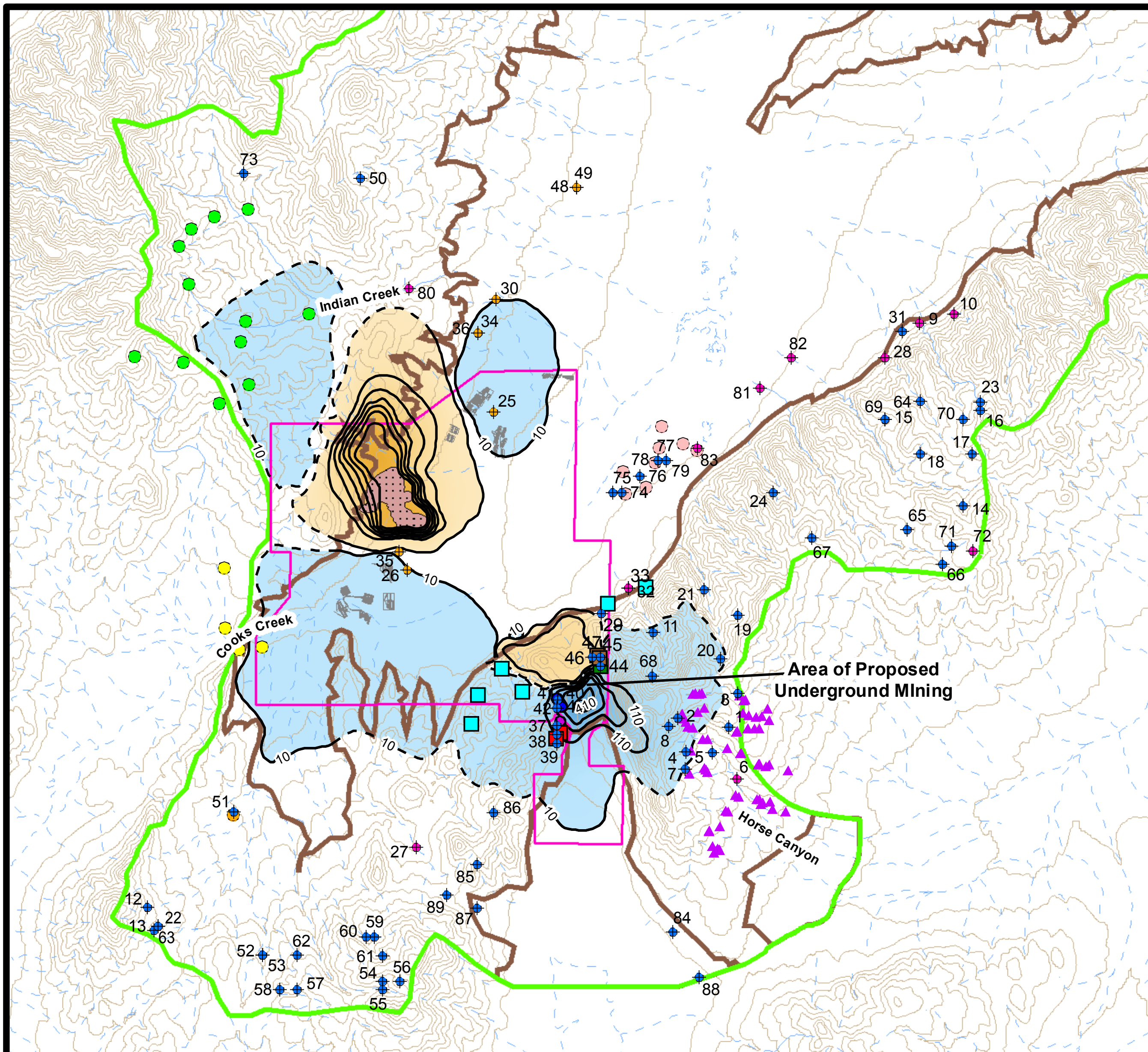
Note: Groundwater level changes compared to estimated groundwater levels at the end of 2004.

Source: Geomega 2006d.

Cortez Hills Expansion Project

Figure 3.2-17
Underground Mine Alternative
Predicted Groundwater
Level Change - 25
Years Post-dewatering

06/20/2007



Monitored Seeps and Springs
- Toiyabe Catchment
- Peripheral
- East Valley
- Shoshone
- Rocky Pass
- Cortez Canyon Seeps
- Mapped Cortez Canyon Spring
- NE Toiyabe Seeps
- NE Corner Seeps and Spring
- NE Survey Area Seep
- Horse Canyon Area

Private Active Water Rights (see **Table B-1** in Appendix B)
- Groundwater
- Streams
- Springs
- Groundwater Level Contours (in feet, dashed where less certain)
- Infiltration Basins
- HSA/Model Domain Boundary
- Elevation Contours (200-foot interval)
- Stream (dashed where intermittent)
- Pipeline Pit
- Project Boundary
- Basin Fill - Bedrock Contact

Groundwater Level Decrease (in feet)
1000
10

Groundwater Level Increase (in feet)
-10
-1000

Note: Groundwater level changes compared to estimated groundwater levels at the end of 2004.

Source: Geomega 2006d.

N

0 1 2 4 Miles

Cortez Hills
Expansion Project

Figure 3.2-18
Underground Mine Alternative
Predicted Groundwater
Level Change -100
Years Post-dewatering

06/20/2007

to be impacted under the No Action Alternative. As with the Proposed Action, this alternative would result in an increase in drawdown (compared to the No Action Alternative) in the east side of Crescent Valley (at the end of mining); and in the region surrounding the underground operation, including the areas beneath the Cortez Mountains (at the end of mining and post-mining period).

Impacts to Perennial Streams and Springs. The potential impacts to streams essentially would be the same as described for the Proposed Action. Based on modeling, this alternative would result in an increase in groundwater drawdown that potentially could further reduce flows and the length of the perennial stream reach for Mill Creek. An increased reduction of flows in Mill Creek would be considered a significant impact. Significant impacts to other streams in the study area are not anticipated.

Potential impacts to springs would be similar to those described for the Proposed Action. There are 48 inventoried perennial springs located within the predicted drawdown area (the area where groundwater levels are predicted to be lowered by 10 feet or more); 25 of these occur in areas where springs potentially could be impacted by drawdown attributable to this alternative (**Table 3.2-12**). Potential impacts to these springs could range from reductions in flow to elimination of all flow. A reduction of flow in these springs would be considered a significant impact. Groundwater levels in the vicinity of springs located in the East Valley group are predicted to eventually recover in the post-mining period (Geomega 2007d). However, 13 of the other 25 springs occur within areas that are predicted to experience long-term drawdown (see **Table 3.2-12**).

Impacts to Water Rights. For the purpose of this evaluation, all water rights owned or controlled by CGM were excluded. As listed in **Table 3.2-17**, there are 10 non-CGM owned or controlled water rights located within the predicted mine-induced groundwater drawdown area (i.e., area where the groundwater levels are predicted to be lowered by 10 feet or more). Of these, six are groundwater rights and four are surface water rights. According to the State Engineer’s records, five of these are used for stock watering, four are used for mining and milling, and one is used for irrigation. As shown in **Table 3.2-17**, the timing and duration of the predicted drawdown would vary by location. Based on the modeling results, the groundwater levels are predicted to fully recover at two locations, partially recovery at five locations, and not fully recover at three locations within 100 years after dewatering ceases.

For surface water rights, the actual potential for impacts to individual water rights would depend on the site-specific hydrologic conditions that control surface water discharge. Only those waters sustained by discharge from the regional groundwater system are likely to be impacted. For surface water rights that are dependent on groundwater discharge, a potential reduction in groundwater levels could reduce or eliminate the flow available at the point of diversion for the surface water right. Impacts to wells could include a reduction in yield, increased pumping cost, or if the water level is lowered below the pump setting or the bottom of the well, make the well unusable. Specific impacts to wells would depend on the site-specific hydrogeologic conditions, wells completion details, and timing of the drawdown.

The actual impacts to individual water rights would depend on the source of groundwater that sustains the water rights and the actual extent of mine-induced drawdown that occurs in the area. The interconnection (or lack of interconnection) between the water rights sources and deeper groundwater sources is controlled

Table 3.2-17
Estimated Water Level Change at Water Rights in the Southern Part of the HSA
(Cortez Hills Complex Underground Mine Alternative)

Map #	Owner of Record	Years After End of Dewatering (change in feet)			
		0	**25**	**50**	**100**
1[1]	Connolly, Thomas	< 0.5	1	3	5
2	Connolly, Thomas	6	**17**	**22**	**26**
3[1]	Cortez Joint Venture	< 0.5	1	2	4
4	Connolly, Thomas	2	9	**13**	**15**
5	Connolly, Thomas	< 0.5	1	1	1
6	Connolly, Thomas	< 0.5	< 0.5	1	1
7	Connolly, Thomas	2	6	7	8
8	Connolly, Thomas	7	**19**	**25**	**29**
9	Dann, Mary	1	2	2	1
10	Dann, Mary	< 0.5	2	2	1
11	Cortez Joint Venture	**16**	**23**	**21**	**19**
12[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
13[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
14[1]	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
15	Cortez Joint Venture	< 0.5	1	1	1
16	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
17	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
18	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
19	Cortez Joint Venture	< 0.5	1	3	5
20[1]	Cortez Joint Venture	< 0.5	5	8	**11**
21	Cortez Joint Venture	< 0.5	3	5	6
22[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
23	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
24	Cortez Joint Venture	2	3	2	1
25	Mill Gulch Placer Mining Company	**58**	**57**	**49**	**44**
26	Filippini, Ed	**17**	**21**	**17**	**11**
27	Filippini, Ed	< 0.5	< 0.5	< 0.5	1
28	Cortez Joint Venture	1	3	2	1
29	Cortez Joint Venture	**66**	**12**	1	-4
30	Little Gem Mining Co.	**17**	**17**	**13**	9
31	Dann, Dewey	1	3	2	1
32	Cortez Joint Venture	**12**	7	3	< 0.5
33	Cortez Joint Venture	**12**	7	3	< 0.5
34	Wright, Elwood	**30**	**25**	**19**	**15**
35	BLM	**15**	**14**	9	2
36	Wright, Elwood	**30**	**25**	**19**	**15**
37	Cortez Joint Venture	**50**	**122**	**141**	**158**
38	Cortez Joint Venture	**36**	**84**	**105**	**124**
39	Cortez Joint Venture	**21**	**52**	**69**	**84**
40	Cortez Joint Venture	**176**	**212**	**215**	**219**
41	Cortez Joint Venture	**176**	**212**	**215**	**219**
42	Cortez Joint Venture	**122**	**213**	**223**	**233**
43	Cortez Joint Venture	**122**	**213**	**223**	**233**
44	Cortez Joint Venture	**394**	**20**	7	3
45	Cortez Joint Venture	**378**	2	-16	-21
46	Cortez Joint Venture	**776**	-124	-139	-146
47	Cortez Joint Venture	**378**	2	-16	-21
48	Nevada Rae Gold Inc.	2	5	3	1
49	Nevada Rae Gold Inc.	2	5	3	1
50	Cortez Joint Venture	1	3	3	2
51	Filippini, Henry	< 0.5	-1	< 0.5	1
52	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
53	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
54[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
55[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5

Table 3.2-17 (Continued)

Map #	Owner of Record	Years After End of Dewatering			
		0	25	50	100
56	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
57	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
58[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
59	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
60	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
61	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
62	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
63[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
64	Cortez Joint Venture	< 0.5	1	1	1
65	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
66	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
67[1]	Cortez Joint Venture	< 0.5	2	2	1
68[1]	Cortez Joint Venture	9	**22**	**25**	**28**
69	Cortez Joint Venture	< 0.5	1	1	1
70	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
71[1]	Tsakopoulos, Angelo K.	< 0.5	< 0.5	< 0.5	< 0.5
72[1]	Tsakopoulos, Angelo K.	< 0.5	< 0.5	< 0.5	< 0.5
73	Julian Tomera Ranches, Inc.	< 0.5	< 0.5	< 0.5	1
74	Cortez Joint Venture	**13**	2	-2	-4
75	Cortez Joint Venture	**13**	2	-1	-4
76	Cortez Joint Venture	**13**	2	-1	-3
77	Cortez Joint Venture	**12**	3	< 0.5	-2
78	Cortez Joint Venture	**12**	3	< 0.5	-2
79	Cortez Joint Venture	**12**	3	< 0.5	-2
80	Wintle, Grace	**26**	**14**	4	-3
81	Cortez Joint Venture	8	4	1	< 0.5
82	Cortez Joint Venture	7	4	2	< 0.5
83	Cortez Joint Venture	**11**	3	< 0.5	-2
84	Connolly, Thomas	< 0.5	< 0.5	< 0.5	< 0.5
85	Cortez Joint Venture	< 0.5	< 0.5	1	2
86	Cortez Joint Venture	< 0.5	1	3	6
87	Cortez Joint Venture	< 0.5	< 0.5	1	1
88[1]	Penola, Edna	< 0.5	< 0.5	< 0.5	< 0.5
89	Filippini Trust	< 0.5	< 0.5	< 0.5	1

Note: Bolded numbers indicate locations within the predicted 10-foot groundwater drawdown contour.

[1] Indicates a private water right located inside the HSA, but in an inactive portion of the groundwater flow model due to model grid discretization. Drawdown was evaluated at the nearest active portion of the model.

Source: Geomega 2006a.

in large part by the specific hydrogeologic conditions that occur at each site. Considering the complexity of the hydrogeologic conditions in the region and the inherent uncertainty in numerical modeling predictions relative to the exact areal extent of a predicted drawdown area, it is not possible to conclusively identify specific water rights that would or would not be impacted by future mine-induced groundwater drawdown.

Impacts to the Water Balance. The water balance for the groundwater system within the HSA was estimated using the groundwater flow model (Geomega 2007d). The estimated annual groundwater inflow and outflow rates under the baseline conditions (2004); end of dewatering; and 25, 50, and 100 years after dewatering are summarized in **Table 3.2-18**. The water balance provides an estimate of the annual change in storage and fluctuations of the major inflow and outflow components over time resulting from the mine dewatering and water management activities. Under the baseline conditions, the water balance illustrates that the annual depletion of water in storage is partially offset by infiltration recharge. The water balance estimates indicate that the mine-induced drawdown associated with mine dewatering is predicted to result in a decrease in evapotranspiration. At 100 years after dewatering ceases, the evapotranspiration rates are predicted to return to baseline conditions, and the water balance would approach equilibrium conditions. The quantity of groundwater that would discharge to the Humboldt River, Pine Valley, and Grass Valley is not predicted to change substantially as a result of the mine dewatering and water management activities. In addition, the predicted long-term loss of groundwater through evaporation from the pit lakes is less than predicted for the Proposed Action.

Table 3.2-18
Simulated Groundwater Budget for the HSA Under the Cortez Hills Complex Underground Mine Alternative (acre-feet per year)

Budget Component	Baseline Conditions (2004)	End of Dewatering	25 Years after Dewatering	50 Years after Dewatering	100 Years after Dewatering
Inflow					
Precipitation Recharge	22,800	22,800	22,800	22,800	22,800
Infiltration Recharge	34,700	2,400	0	0	0
Subsurface Inflow (Rocky Pass)	300	300	300	300	300
Pit Lakes	0	700	200	0	0
Total Inflow	57,800	26,200	23,300	23,100	23,100
Outflow					
Evapotranspiration	16,300	10,700	12,800	14,900	16,600
Subsurface Outflow					
Grass Valley	1,300	1,300	1,300	1,300	1,200
Pine Valley	400	400	400	400	400
Mine Dewatering	37,600	14,200	0	0	0
Consumptive Use	2,900	2,600	2,600	2,600	2,600
Pit Lakes	0	5,200	2,100	1,300	1,100
Outflow to Humboldt River	400	400	400	400	400
Total Outflow	58,900	34,800	19,600	20,900	22,300
Inflow Minus Outflow	-1,100	-8,600	3,700	2,200	800

Source: Geomega 2007d.

Water Quality Impacts

The deeper levels of the underground workings would be below the pre-mining water table. Underground mining would extract up to 12 million tons of ore from below the pre-mining water table. During underground operations, the underground workings below the pre-mining water table would be backfilled with a cemented waste rock backfill. Due to the difference in densities between in situ ore and cemented backfill, the tonnage of the backfill would be approximately 73 percent of the ore tonnage, or approximately up to 9 million tons. As the groundwater elevation recovers and saturates a portion of the underground workings, both the exposed wall rock and the backfilled waste rock would interact with groundwater and potentially affect its chemical composition.

Geomega (2007d) developed a conceptual model of water-rock interaction processes that would affect groundwater chemistry under this alternative. During the mining period, wall and waste rock materials would be dewatered and in contact with the atmosphere, allowing oxidation of minerals such as pyrite. During the initial infilling period, wall and waste rock in the underground workings would continue to oxidize, and the influent water would equilibrate with the near-atmospheric gas composition of the underground workings. As the system transitions from infilling to throughflow, the water in the underground workings would no longer equilibrate with atmospheric gases, and the system would move toward ambient baseline aquifer oxidation-reduction and carbon dioxide partial pressure conditions. Groundwater that moves through the oxidized waste rock and wall rock would dissolve solutes produced by mineral oxidation, influencing the groundwater quality.

Groundwater chemistry was modeled by integrating the quantity and quality of groundwater inflow, pyrite oxidation rates in the exposed wall rock and waste rock, and aqueous geochemical reactions in the area of underground mining. The groundwater flow model was used to predict the infilling rate and distribution of groundwater flow as a function of time. Infilling rates determine the duration of wall rock and waste rock exposure and the time during which pyrite oxidation would occur. The pyrite oxidation model was used to predict the oxidized volume from which solutes would be available for leaching into the influent groundwater. The rock type distribution in the underground workings would consist of 98 percent Cortez Hills marble, 1 percent dike, and 1 percent refractory. The oxidation rates assumed by Geomega (2007d) for these wall rock types were identical to those used in the Proposed Action and No Action Alternative pit lake chemistry evaluations (Geomega 2007a). Waste rock oxidation rates were determined using the same methodology as for the wall rock (Geomega 2007d); this analysis took into account the higher porosity of the waste rock, which resulted in an increased oxidized thickness of the waste rock. Chemical release functions generated by leaching tests were used to determine the amounts of solutes released to the inflowing groundwater from the oxidized wall rock and waste rock. The chemistry of the water that encountered each rock unit was determined by integrating the chemical release functions of each unit with respect to pore volume over the period of interest and adding this solute loading to the chemistry of the influent background groundwater (Geomega 2007d).

The geochemical mixing model was used to combine the groundwater flow, groundwater quality, and chemical release results and to predict the final groundwater chemistry based on the results of the reactions between the mixing waters (Geomega 2007d). The groundwater chemistry for the underground mining alternative was modeled in one-flush time steps (Geomega 2007d). The first flush consisted of the water in the area of the underground workings at the end of the initial 3-year infilling period. The modeling continued through five flushes up to 148 years (**Table 3.2-19**).

Table 3.2-19
Comparison of Predicted Water Chemistry in Underground Workings to Baseline Groundwater, Proposed Action Cortez Hills Pit Lake, and Water Quality Standards

Parameter[1]	Applicable Nevada Water Quality Standards[2]	Proposed Action Cortez Hills Pit Lake (100 years)	Background Groundwater (0 years)	Cortez Hills Complex Underground Mine Alternative				
				First Flush (3 years)	Second Flush (13 years)	Third Flush (30 years)	Fourth Flush (65 years)	Fifth Flush (148 years)
Silver	0.1[3]	0.004	0.003	0.008	0.008	0.008	0.008	0.008
Aluminum	0.05[4], 0.2[3]	0.04	0.03	0.02	0.02	0.02	0.02	0.02
Arsenic[1]	0.05[5]	0.026	0.019	0.045	0.047	0.048	0.049	0.047
Boron	--	0.17	0.11	0.15	0.15	0.15	0.15	0.15
Barium	2	0.06	0.09	0.08	0.08	0.08	0.08	0.08
Beryllium	0.004	<0.001	0.001	0.002	0.003	0.003	0.003	0.003
Alkalinity	--	175	163	174	179	178	177	175
Calcium	--	22.2	33.7	35.8	35.8	35.5	35.1	34.3
Cadmium	0.005	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Chloride	250[4], 400[3]	46	30	33	31	30	30	30
Chromium	0.01	0.005	0.004	0.01	0.01	0.01	0.01	0.01
Copper	1.0[3],1.3[6]	0.006	0.004	0.007	0.008	0.007	0.007	0.007
Fluoride	2.0[4], 4.0[3]	0.7	0.5	0.6	0.6	0.6	0.6	0.6
Iron	0.3[4], 0.6[3]	0.01	0.06	0.01	0.08	0.1	0.1	0.1
Mercury	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Potassium	--	11.6	7.4	10.1	9.9	9.7	9.4	9.0
Magnesium	125[4], 150[3]	23.1	14.8	15.9	15.8	15.7	15.5	15.3
Manganese	0.05[4], 0.1[3]	0.001	0.01	0.001	0.025	0.012	0.012	0.012
Nitrate (as N)	10	0.8	0.5	0.6	0.6	0.6	0.6	0.6
Sodium	--	53	34	36	36	35	35	35
Nickel	0.1	0.008	0.005	0.015	0.015	0.015	0.017	0.017
Lead	0.015[6]	0.003	0.003	0.007	0.008	0.008	0.008	0.008
pH[2]	6.5-8.5[3]	8.32	8.27	8.1	8.08	8.09	8.1	8.11
Sulfate	500[4], 1000[3]	54	35	42	42	41	40	39
Antimony[3]	0.146[5]	0.004	0.003	0.006	0.006	0.006	0.006	0.006
Selenium	0.05	0.008	0.005	0.016	0.015	0.015	0.015	0.015
Thallium	0.002	0.001	0.001	0.003	0.003	0.003	0.003	0.003
Zinc	5.0[3]	0.006	0.004	0.009	0.009	0.009	0.009	0.009
TDS	500[4], 1,000[3]	387	319	348	350	347	344	338

1 Units are mg/L unless otherwise noted.
2 Nevada primary MCLs unless otherwise noted. Federal primary standards of July 1, 1993, are incorporated by reference in NAC 445A.453.
3 Nevada secondary MCLs.
4 Federal secondary MCLs.
5 Federal primary MCL for arsenic is 0.01 mg/L; federal primary MCL for antimony is 0.006 mg/L.
6 Value is action level for treatment technique for lead and copper.

Sources: 40 CFR 141.51; 40 CFR 143.3; Geomega 2007d; NAC 445A.119, 445A.144, 445A.453, and 445A.455.

Based on the geochemical mixing model results, Geomega (2007d) concluded that most solute flushing would occur during the first 25 years. As recovery occurs, the bulk groundwater chemistry is predicted to trend back toward baseline water chemistry, including more reducing conditions.

After the second flush, the pH of the groundwater declined slightly from the background value of 8.27 to 8.08 (**Table 3.2-19**). This slight pH decrease is the result of pyrite oxidation during the mining and infilling period (Geomega (2007d). As groundwater conditions recover, the pH is predicted to slowly increase toward ambient conditions. Calcite, otavite, gibbsite, barite, and AFH all were predicted to precipitate from solution. However, AFH would become unstable after the initial infilling period as more reducing conditions characteristic of the ambient groundwater become established. TDS values in the groundwater are predicted to be moderate and less than water quality standards. Predicted thallium concentrations would slightly exceed water quality standards (**Table 3.2-19**), but this predicted result may have been caused by the proximity of the analytical detection limit (0.001 mg/L) to the water quality standard (0.002 mg/L) (Geomega 2007d) and use of one-half of the detection limit for numerous below detection limit analyses (Geomega 2007a). All other constituents had predicted concentrations below applicable water quality standards (**Table 3.2-19**).

The water quality predicted for the Cortez Hills Complex Underground Mine Alternative and the Proposed Action Cortez Hills Pit lake were very similar (**Table 3.2-15**). Slightly lower major-element concentrations (e.g., sodium and sulfate) are predicted for the underground mining alternative due to the lack of evapoconcentration that would occur in the pit lake under the Proposed Action (Geomega 2007d). Slightly higher metals concentrations are predicted for the underground mining alternative. These higher concentrations would occur due to the long-term reducing conditions that would prevent the persistence of AFH and its sorbed metals and due to the presence of waste rock, which would provide additional solutes to the influent groundwater (Geomega 2007d). For the underground mining alternative, water quality is predicted to be within applicable standards, with the possible exception of thallium. However, the predicted thallium concentrations are believed to be artificially elevated due to the proximity of the standard to analytical detection limit (Geomega 2007d). Therefore, operations under the Cortez Hills Complex Underground Mine Alternative are not expected to significantly impact water quality.

Erosion, Sedimentation, and Flooding

Under this alternative, state and federal regulatory requirements, permit approval processes, and CGM's committed environmental protection measures (as presented in Section 2.4.11) would be similar to those for the Proposed Action. There would be little, if any, impact to surface water resources from most of the project facilities associated with this alternative. However, the partial obstruction of the delineated floodplain in upper Crescent Valley would still take place as a result of the Pipeline Waste Rock Facility expansion, as described for the Proposed Action. Potential impacts related to flood flow conditions, erosion and sedimentation, and other potential damages would be the same as those described for the Proposed Action.

3.2.2.6 No Action Alternative

Under the No Action Alternative, the proposed Cortez Hills Expansion Project would not be developed, and the associated impacts would not occur. Under this alternative, both the existing Pipeline/South Pipeline Project and Cortez Mine Underground Exploration Project would continue to operate under existing authorizations. The currently authorized dewatering and water management operations for these projects are summarized in Section 2.5.1.4, No Action Alternative; annualized average dewatering and infiltration rates are summarized in **Tables 3.2-9** and **3.2-10**, respectively.

Water Quantity Impacts

Impacts to Water Levels. Potential changes in water levels in the groundwater system were evaluated using the methodology previously described in Section 3.2.2.1, Evaluation Methodology. The predicted change in groundwater levels attributable to the No Action Alternative at the end of dewatering, 25 years after dewatering, and 100 years after dewatering are provided in **Figures 3.2-19**, **3.2-20**, and **3.2-21**, respectively. These figures show areas where the water levels are predicted to decrease or increase over time in comparison to the baseline groundwater elevations at the end of 2004. At the end of dewatering, two distinct drawdown areas would develop: one centered on the Pipeline Complex and one centered on the Cortez Complex. In the vicinity of the Cortez Complex, comparison of the three periods indicates that the maximum extent of the 10-foot drawdown contour is predicted to occur at the end of dewatering in most areas with the exception of a few isolated areas east of the mine that appear at 25 years after dewatering. The groundwater divide between Crescent and Grass valleys is not predicted to shift as a result of the mine-induced drawdown. In addition, nearly all of the drawdown is predicted to fully recover prior to 100 years post-mining.

As with the Proposed Action, the No Action Alternative is not predicted to impact water levels in the vicinity of Crescent Valley Township or in the northern portion of Crescent Valley and in the vicinity of the Humboldt River (Geomega 2007f).

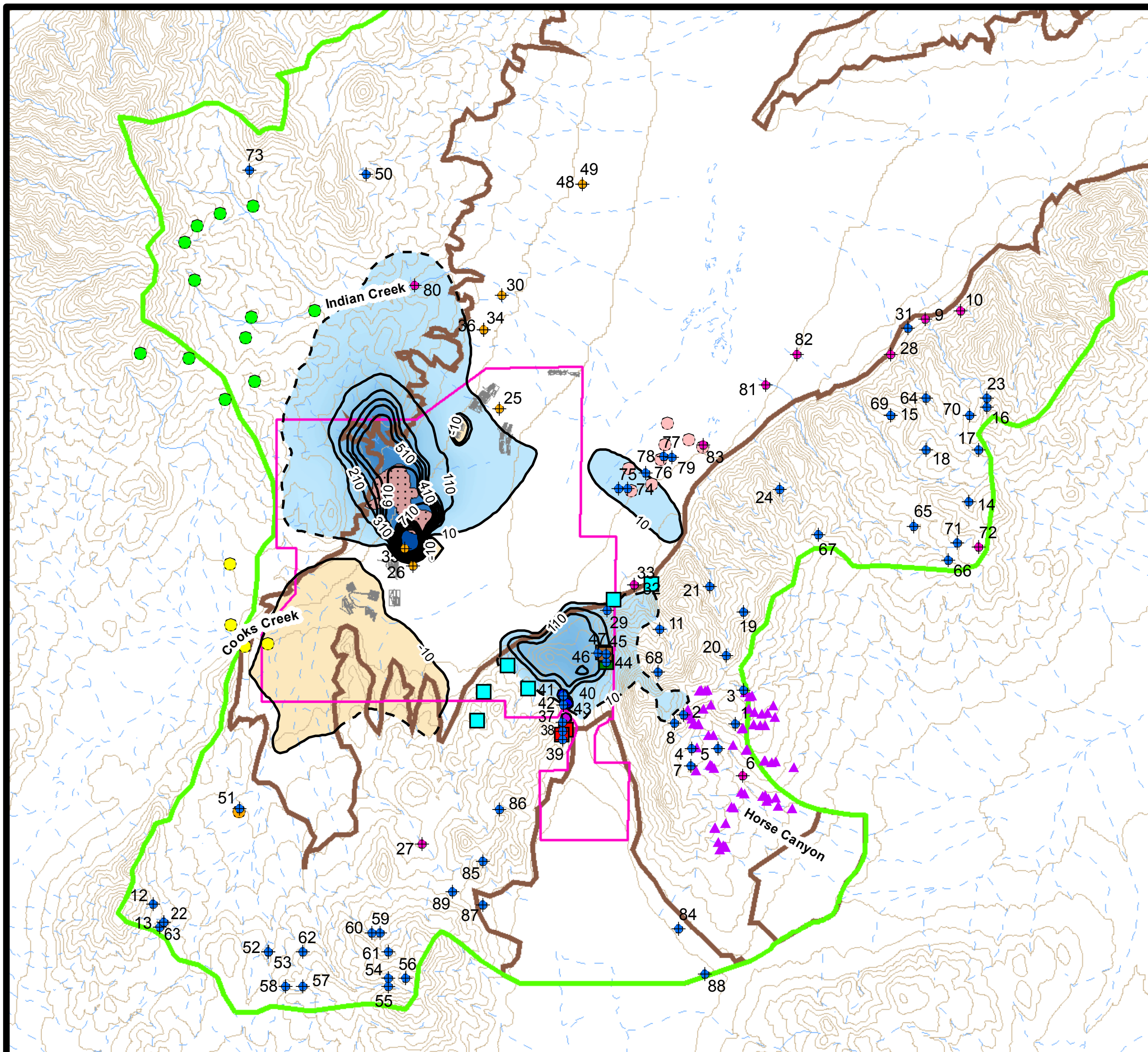
Pit Lake Development. Following the completion of the currently permitted mining and dewatering activities, three pit lakes are predicted to form under the No Action Alternative. These include the Crossroads and Gap pit lakes in the Pipeline Pit and a small pit lake in the existing Cortez Pit. The rate of development is shown in **Figure 3.2-22**, and physical conditions are summarized in **Table 3.2-20**. The location, surface area, and surface configuration of the Gap, Crossroads, and Cortez pit lakes would be essentially the same as previously described for the Proposed Action (Section 3.2.2.2). As shown on the hydrograph in **Figure 3.2-22**, the Crossroads Pit lake would develop rapidly with more than 80 percent of the recovery occurring within 10 years of the end of dewatering. The Gap and Cortez pit lakes would fill more slowly at later states of the post-mining period controlled in large part by their higher pit floor elevations. At 100 years post-mining, all three pits are predicted to behave as sinks with no outflow to the groundwater system (Geomega 2007f).

Table 3.2-20
Summary of Predicted Post-mining Pit Lakes at 100 Years Under the No Action Alternative

Pit Lake Location	Surface Area (acre)	Volume (acre-feet)	Lake Surface Elevation (feet amsl)	Pit Floor Elevation (deepest) (feet amsl)	Maximum Depth (feet)	Evaporative Loss (acre-feet/year)	Groundwater Outflow (yes/no) (acre-feet/year)
Cortez Pit	6	65	4,803	4,760	43	18	No
Pipeline Pit Complex							
Crossroads Pit	269	142,634	4,768	3,400	1,368	928	No
Gap Pit	33	5,944	4,752	4,400	352	114	No

Source: Geomega 2007f.

Impacts to Perennial Streams and Springs. The methodology used to identify potential impacts to perennial streams, springs, and seeps is the same as described for the Proposed Action in Section 3.2.2.2. In summary, the model simulated drawdown area for the No Action Alternative extends into the Shoshone Range northwest of the Pipeline Pit area. In addition, drawdown predicted at the end of mining extends into



Monitored Seeps and Springs
- Toiyabe Catchment
- Peripheral
- East Valley
- Shoshone
- Rocky Pass
- Cortez Canyon Seeps
- Mapped Cortez Canyon Spring
- NE Toiyabe Seeps
- NE Corner Seeps and Spring
- NE Survey Area Seep
- Horse Canyon Area

Private Active Water Rights (see **Table B-1** in Appendix B)
- Groundwater
- Streams
- Springs
- Groundwater Level Contours (in feet, dashed where less certain)
- Infiltration Basins
- Model Domain
- Elevation Contours (200-foot interval)
- Stream (dashed where intermittent)
- Project Boundary
- Pipeline Pit
- Basin Fill - Bedrock Contact

Groundwater Level Decrease (in feet)
1000
10

Groundwater Level Increase (in feet)
-10
-1000

Note: Groundwater level changes compared to estimated groundwater levels at the end of 2004.

Source: Geomega 2007f.

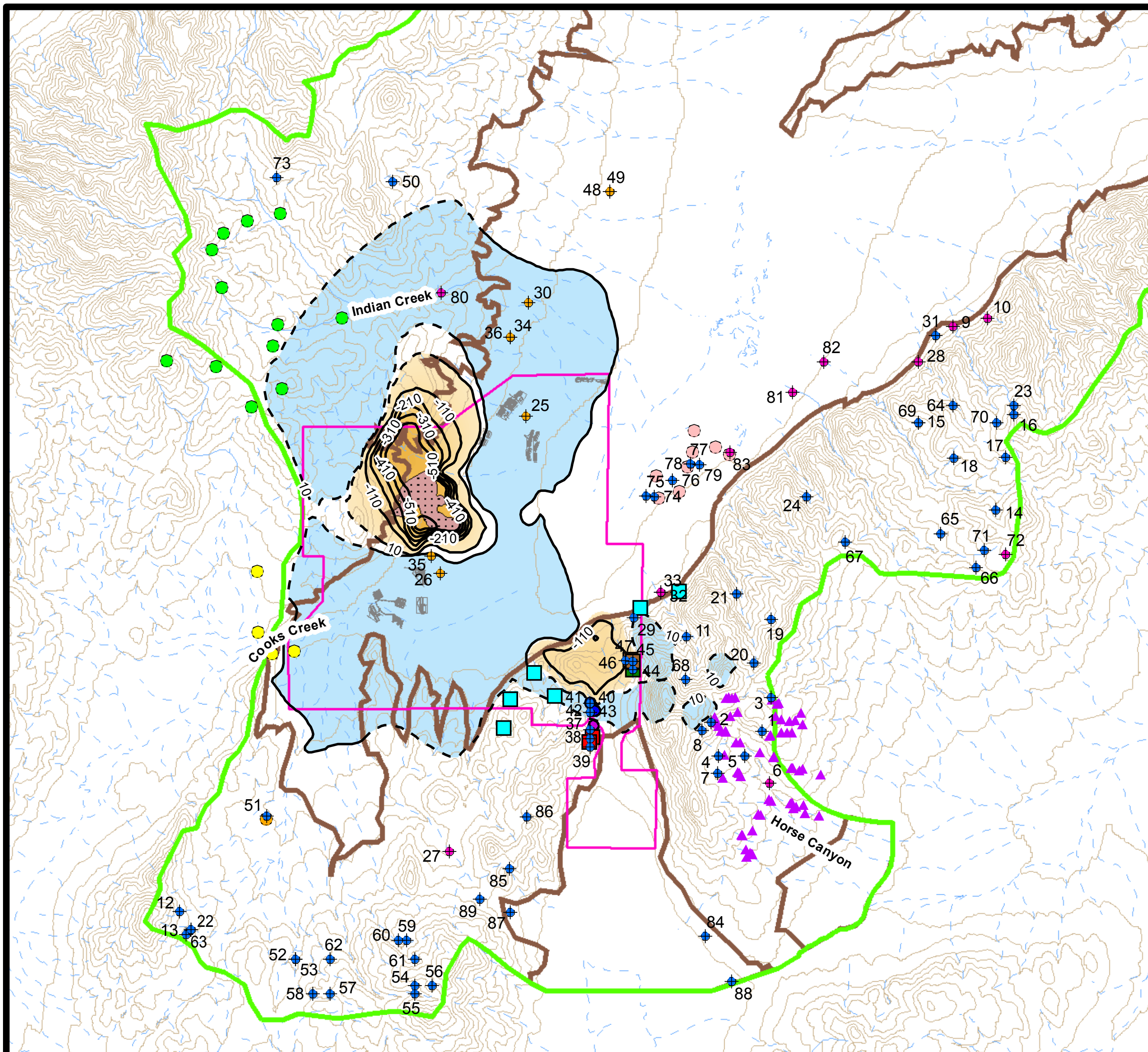
N

0 1 2 4 Miles

Cortez Hills Expansion Project

Figure 3.2-19
No Action Alternative
Predicted Groundwater Level Change -
End of Dewatering

06/19/2007



Monitored Seeps and Springs
- Toiyabe Catchment
- Peripheral
- East Valley
- Shoshone
- Rocky Pass
- Cortez Canyon Seeps
- Mapped Cortez Canyon Spring
- NE Toiyabe Seeps
- NE Corner Seeps and Spring
- NE Survey Area Seep
- Horse Canyon Area

Private Active Water Rights (see **Table B-1** in Appendix B)
- Groundwater
- Streams
- Springs

Groundwater Level Contours (in feet, dashed where less certain)
Model Domain
Infiltration Basins
Elevation Contours (200-foot interval)
Stream (dashed where intermittent)
Pipeline Pit
Project Boundary
Basin Fill - Bedrock Contact

Groundwater Level Decrease (in feet)
1000
10

Groundwater Level Increase (in feet)
-10
-1000

Note: Groundwater level changes compared to estimated groundwater levels at the end of 2004.

Source: Geomega 2007f.

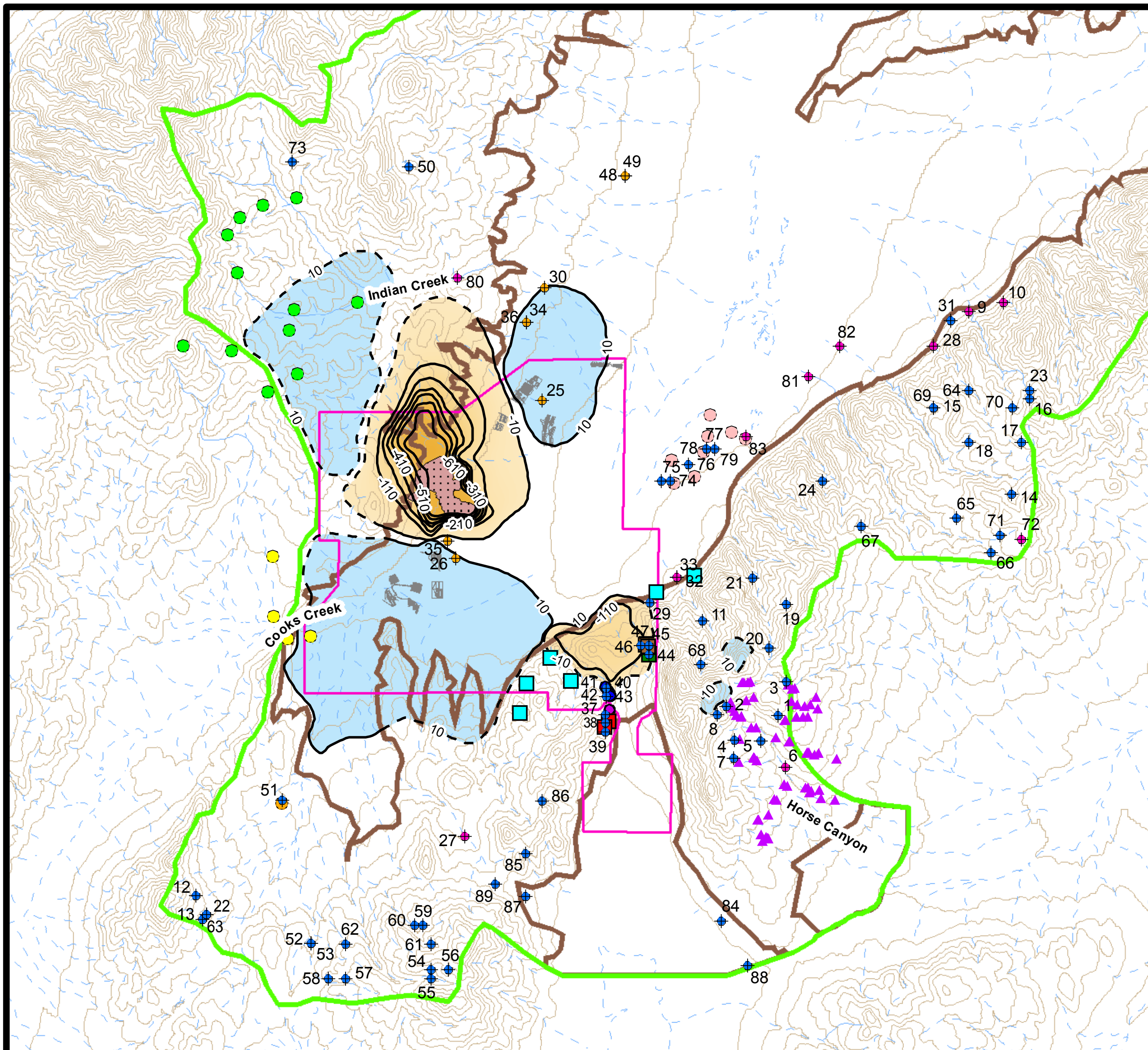
N

0 1 2 4 Miles

Cortez Hills Expansion Project

Figure 3.2-20
No Action Alternative
Predicted Groundwater
Level Change - 25 Years
Post-dewatering

06/19/2007



Monitored Seeps and Springs
- Toiyabe Catchment
- Peripheral
- East Valley
- Shoshone
- Rocky Pass
- Cortez Canyon Seeps
- Mapped Cortez Canyon Spring
- NE Toiyabe Seeps
- NE Corner Seeps and Spring
- NE Survey Area Seep
- Horse Canyon Area

Private Active Water Rights (see **Table B-1** in Appendix B)
- Groundwater
- Streams
- Springs
- Groundwater Level Contours (in feet, dashed where less certain)
- Model Domain
- Infiltration Basins
- Stream (dashed where intermittent)
- Elevation Contours (200-foot interval)
- Pipeline Pit
- Project Boundary
- Basin Fill - Bedrock Contact

Groundwater Level Decrease (in feet)
1000
10

Groundwater Level Increase (in feet)
-10
-1000

Note: Groundwater level changes compared to estimated groundwater levels at the end of 2004.

Source: Geomega 2007f.

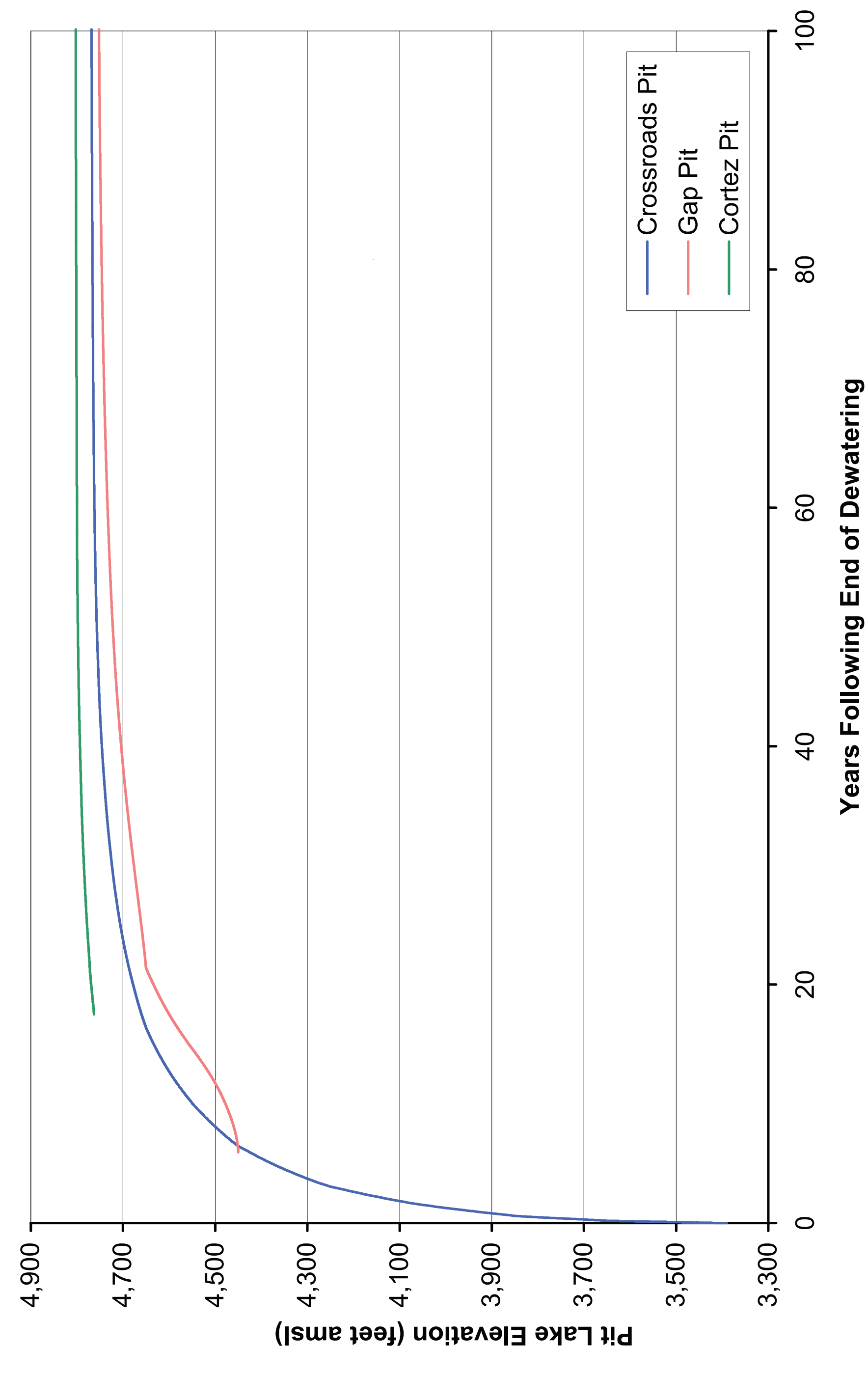
N

0 1 2 4 Miles

Cortez Hills Expansion Project

Figure 3.2-21
No Action Alternative
Predicted Groundwater
Level Change -100 Years
Post-dewatering

06/19/2007



Source: Geomega 2007f.

Note: The Crossroads and Gap pits are the southeastern and western portions, respectively, of the currently approved Pipeline Pit (see **Figure 2-9**).

Cortez Hills
Expansion Project

Figure 3.2-22

Rate of Pit Lake Development
Under the
No Action Alternative

Mill Creek. Perennial flow in these stream reaches could be controlled by discharge from perched aquifers or compartmentalized groundwater systems that are hydraulically isolated from the regional groundwater system that would be affected by drawdown. However, the interconnection between this perennial stream reach and the regional bedrock system that would be impacted by long-term, mine-induced drawdown is not well understood. Considering the uncertainty, this analysis conservatively assumed that perennial flows in Indian, Feris, and Mill creeks could be interconnected to the regional bedrock groundwater system and therefore could be impacted. A reduction in groundwater levels potentially could reduce flows and possibly reduce the length of the perennial stream reach. A reduction of flows in these perennial reaches would be considered a significant impact. Significant impacts to other streams in the study area are not anticipated.

As presented in **Table 3.2-12,** there are 20 inventoried perennial springs located within the predicted drawdown area. These springs are located in the Cortez Hills area, and in the Rocky Pass, Toiyabe Catchment, Shoshone Range, and East Valley spring groups. Excluding the East Valley Springs group, which appears to be connected to the basin fill aquifer in Crescent Valley (Geomega 2007f), the interconnection between springs in the other groups and the regional bedrock system that could be impacted by long-term, mine-induced drawdown is not well understood. Considering the uncertainty**,** this analysis conservatively assumed spring discharge in these areas could be interconnected to the regional bedrock groundwater system and therefore could be impacted. Potential impacts to these springs could range from reductions in flow to elimination of flow. Groundwater levels in the vicinity of 18 of the 20 springs are predicted to eventually recover in the post-mining period (Geomega 2007f). However, 2 other springs occur within areas that are predicted to experience long-term drawdown that is not expected to fully recover within 100 years. A reduction of flows in these springs would be considered a significant impact.

Impacts to Water Rights. For the purpose of this evaluation, all water rights owned or controlled by CGM were excluded. Under this alternative, potential impacts to water rights would be the same as described for the Proposed Action, with the following exception. As listed in **Table 3.2-21**, there are six non-CGM owned or controlled water rights located within the predicted mine-induced drawdown area (i.e., area where the groundwater levels are predicted to be lowered by 10 feet or more). Of these, five are groundwater rights and one is a surface water right. According to the State Engineer's records, two of these are used for stock watering, four are used for mining and milling, and one is used for irrigation. As shown in **Table 3.2-21**, the timing and duration of the predicted drawdown varies for the different locations. Based on the modeling results, full recovery of the groundwater levels is predicted at two locations, and partial recovery is predicted at the remaining four locations within 100 years after dewatering ceases.

Impacts to the Regional Water Balance. The water balance for the groundwater system within the HSA was estimated using the groundwater flow model (Geomega 2007f). The estimated annual groundwater inflow and outflow rates under the baseline conditions (2004); end of dewatering; and 25, 50, and 100 years after dewatering for the No Action Alternative are summarized in **Table 3.2-22**. The water balance provides an estimate of the annual change in storage and fluctuations of the major inflow and outflow components over time resulting from the mine dewatering and water management activities. The projected pattern of changes in the water balance for the No Action Alternative over the post-dewatering period is similar to the impacts previously described for the Proposed Action (Section 3.2.2.2).

Table 3.2-21
Estimated Water Level Change at Water Rights in the Southern Part of the HSA
(No Action Alternative)

Map #	Owner of Record	Years after End of Dewatering (change in feet)			
		0	25	50	100
1[1]	Connolly, Thomas	< 0.5	< 0.5	< 0.5	< 0.5
2	Connolly, Thomas	1	3	3	3
3[1]	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
4	Connolly, Thomas	< 0.5	1	1	1
5	Connolly, Thomas	< 0.5	< 0.5	< 0.5	< 0.5
6	Connolly, Thomas	< 0.5	< 0.5	< 0.5	< 0.5
7	Connolly, Thomas	< 0.5	< 0.5	< 0.5	< 0.5
8	Connolly, Thomas	< 0.5	2	2	2
9	Dann, Mary	< 0.5	2	1	1
10	Dann, Mary	< 0.5	1	1	1
11	Cortez Joint Venture	5	9	5	2
12[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
13[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
14[1]	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
15	Cortez Joint Venture	< 0.5	1	1	1
16	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
17	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
18	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
19	Cortez Joint Venture	< 0.5	< 0.5	1	1
20[1]	Cortez Joint Venture	< 0.5	1	2	2
21	Cortez Joint Venture	< 0.5	2	3	3
22[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
23	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
24	Cortez Joint Venture	1	3	2	1
25	Mill Gulch Placer Mining Company	2	**59**	**49**	**44**
26	Filippini, Ed	-5	**19**	**17**	**12**
27	Filippini, Ed	< 0.5	< 0.5	< 0.5	< 0.5
28	Cortez Joint Venture	1	2	2	1
29	Cortez Joint Venture	**33**	**10**	< 0.5	-4
30	Little Gem Mining Co.	< 0.5	**18**	**13**	**10**
31	Dann, Dewey	< 0.5	2	2	1
32	Cortez Joint Venture	8	6	3	< 0.5
33	Cortez Joint Venture	8	6	3	< 0.5
34	Wright, Elwood	4	**27**	**19**	**14**
35	BLM	**1,245**	**13**	9	3
36	Wright, Elwood	4	**27**	**19**	**14**
37	Cortez Joint Venture	2	6	5	4
38	Cortez Joint Venture	1	4	4	3
39	Cortez Joint Venture	1	2	3	2
40	Cortez Joint Venture	**23**	**15**	5	-3
41	Cortez Joint Venture	**23**	**15**	5	-3
42	Cortez Joint Venture	9	**19**	**11**	4
43	Cortez Joint Venture	9	**19**	**11**	4
44	Cortez Joint Venture	**109**	-25	-40	-44
45	Cortez Joint Venture	**123**	-22	-40	-46
46	Cortez Joint Venture	**216**	-105	-124	-129
47	Cortez Joint Venture	**123**	-22	-40	-46
48	Nevada Rae Gold Inc.	< 0.5	4	3	1
49	Nevada Rae Gold Inc.	< 0.5	4	3	1
50	Cortez Joint Venture	1	3	3	2
51	Filippini, Henry	< 0.5	-1	< 0.5	< 0.5
52	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
53	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
54[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
55[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5

Table 3.2-21 (Continued)

Map #	Owner of Record	Years after End of Dewatering			
		0	25	50	100
56	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
57	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
58[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
59	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
60	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
61	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
62	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
63[1]	Filippini, Henry	< 0.5	< 0.5	< 0.5	< 0.5
64	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
65	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
66	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
67[1]	Cortez Joint Venture	< 0.5	1	1	1
68[1]	Cortez Joint Venture	1	5	4	3
69	Cortez Joint Venture	< 0.5	1	1	1
70	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
71[1]	Tsakopoulos, Angelo K.	< 0.5	< 0.5	< 0.5	< 0.5
72[1]	Tsakopoulos, Angelo K.	< 0.5	< 0.5	< 0.5	< 0.5
73	Julian Tomera Ranches, Inc.	< 0.5	< 0.5	< 0.5	< 0.5
74	Cortez Joint Venture	**11**	2	-1	-4
75	Cortez Joint Venture	**11**	3	-1	-3
76	Cortez Joint Venture	**10**	3	-1	-3
77	Cortez Joint Venture	9	3	< 0.5	-2
78	Cortez Joint Venture	9	3	< 0.5	-2
79	Cortez Joint Venture	9	3	< 0.5	-2
80	Wintle, Grace	**15**	**17**	5	-2
81	Cortez Joint Venture	5	4	1	< 0.5
82	Cortez Joint Venture	3	4	2	< 0.5
83	Cortez Joint Venture	8	3	< 0.5	-1
84	Connolly, Thomas	< 0.5	< 0.5	< 0.5	< 0.5
85	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
86	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
87	Cortez Joint Venture	< 0.5	< 0.5	< 0.5	< 0.5
88[1]	Penola, Edna	< 0.5	< 0.5	< 0.5	< 0.5
89	Filippini Trust	< 0.5	< 0.5	< 0.5	< 0.5

Note: Bolded numbers indicate locations within the predicted 10-foot groundwater drawdown contour.

[1] Indicates a private water right located inside the HSA, but in an inactive portion of the groundwater flow model due to model grid discretization. Drawdown was evaluated at the nearest active portion of the model.

Source: Geomega 2007f.

Table 3.2-22
Simulated Groundwater Budget for the HSA Under the No Action Alternative
(acre-feet per year)

Budget Component	Baseline Conditions (2004)	End of Dewatering	25 Years after Dewatering	50 Years after Dewatering	100 Years after Dewatering
Inflow					
Precipitation Recharge	22,800	22,800	22,800	22,800	22,800
Infiltration Recharge	34,700	29,700	0	0	0
Subsurface Inflow (Rocky Pass)	300	300	300	300	300
Pit Lakes	0	0	400	100	500
Total Inflow	57,800	52,800	23,500	23,200	23,100
Outflow					
Evapotranspiration	16,300	11,200	11,600	12,900	17,000
Subsurface Outflow					
Grass Valley	1,300	1,300	1,300	1,300	1,300
Pine Valley	400	400	400	400	400
Mine Dewatering	37,600	46,200	0	0	0
Consumptive Use	2,900	2,900	2,600	2,600	2,600
Pit Lakes	0	0	4,700	2,800	2,000
Outflow to Humboldt River	400	400	400	400	400
Total Outflow	58,900	62,400	21,000	20,400	23,700
Inflow Minus Outflow	-1,100	-9,600	2,500	2,800	-600

Source: Geomega 2007f.

Water Quality Impacts

Pit Lake Water Quality. The chemistry of the Pipeline post-mining pit lakes (Gap and Crossroads) was modeled for the No Action Alternative using the methods described in Section 3.2.2.1, Evaluation Methodology. The predicted water chemistry data for these two pit lakes after 100 years are summarized in **Table 3.2-15**. Under this alternative, the Gap Pit lake water is predicted to have a mildly alkaline pH, with TDS concentrations greater than Nevada secondary water quality standards. The Gap Pit lake also is predicted to have antimony and fluoride concentrations that exceed federal primary water quality standards; the predicted arsenic concentration is less than the Nevada standard, but exceeds the federal standard. Predicted constituent concentrations in the Gap Pit lake under the No Action Alternative are similar to the concentrations predicted under the Proposed Action (**Table 3.2-15**). Under the No Action Alternative, Gap Pit lake would not contain translocated waste rock below the ultimate pit lake water level. In addition, it would have a decreased surface area to volume ratio that would result in a lower evapoconcentration rate. As a result, the predicted Gap Pit lake water quality under the No Action Alternative is slightly better than the predicted water quality under the Proposed Action.

Under the No Action Alternative, the Crossroads Pit lake water is predicted to be mildly alkaline and meet all primary water quality standards (**Table 3.2-15**). Predicted fluoride, sulfate, and TDS concentrations exceed federal secondary standards, but are below the Nevada secondary MCLs. The predicted water quality for the Crossroads Pit lake is similar to the predicted water quality under the Proposed Action, with slightly lower concentrations of some major constituents (chloride, magnesium, sulfate, and TDS) predicted for the No Action Alternative. The predicted chemistry for the pit lakes are similar because the ultimate pit surface would be the same under both alternatives, and only minor changes in pit infilling hydrodynamics are expected. The Cortez Pit lake that would form under the No Action Alternative is expected to have essentially the same chemical composition as the historic Cortez Pit lake. As a result, the Cortez Pit lake water chemistry is anticipated to be similar to background water chemistry.

Infiltration Basins. Under the No Action Alternative water from the dewatering operations would continue to be discharged to the Highway Area, the Rocky Pass Area, and the Windmill Area. The Filippini infiltration site is no longer in service. The Frome site is not currently being used for infiltration. Predicted dewatering rates are slightly higher than the 2006 rate of 28,100 gpm. The effect of past dewatering has been to cause groundwater mounds below the infiltration ponds. The rising groundwater has caused dissolution of salts present in the vadose zone. These salts had been deposited by natural evaporation over a long period of time. The salinity in the groundwater mounds is initially elevated as a result of dissolution of these soluble salts.

The high salinity is a transient event. The soluble salts are dissolved in the first few pore volumes of infiltrating water; additional inputs of water do not cause dissolution of substantial additional amounts of soluble salts. The chemistry of the water pumped in the dewatering operations generally is similar to that of the existing groundwater in Crescent Valley.

With continued operation of the infiltration ponds, the higher-salinity water presently located below the ponds would mix with the existing groundwater and move down the valley. The salinity would be reduced by mixing and dispersion. In view of the small volumes of saline water, it is unlikely that the increased salinity would cause exceedances of groundwater quality standards away from the immediate areas of the infiltration ponds. (Note: Groundwater downgradient from the infiltration ponds is and would continue to be monitored as recommended by NDEP [NDEP 2005]).

Erosion, Sedimentation, and Flooding

Under the No Action Alternative, potential impacts to surface water resources would be the same as those described in previous NEPA analyses for the existing mining and processing facilities. The types of impacts that could affect surface water resources would be generally similar in nature to those described for the Proposed Action, but they would differ in their degree, extent, and location as described in the Pipeline/South Pipeline Pit Expansion Project Final SEIS (BLM 2004e) and other previous NEPA documents. Similarly, CGM's existing committed environmental protection measures and regulatory compliance programs are similar to those described for the Proposed Action. CGM would continue to comply with federal and state permit authorizations and regulatory requirements.

Under the No Action Alternative, the partial obstruction of the floodplain delineated in Crescent Valley from the Pipeline Waste Rock Facility Expansion and the rerouting of CR 225 would not occur. The interruption of ephemeral or intermittent stream channels by project components in the proposed Cortez Hills Complex (see **Figure 2-3**) would not occur. As a result, potential impacts from erosion, sedimentation, or flooding from modified drainage patterns would not occur.

3.2.3 Cumulative Impacts

Water Quantity Impacts

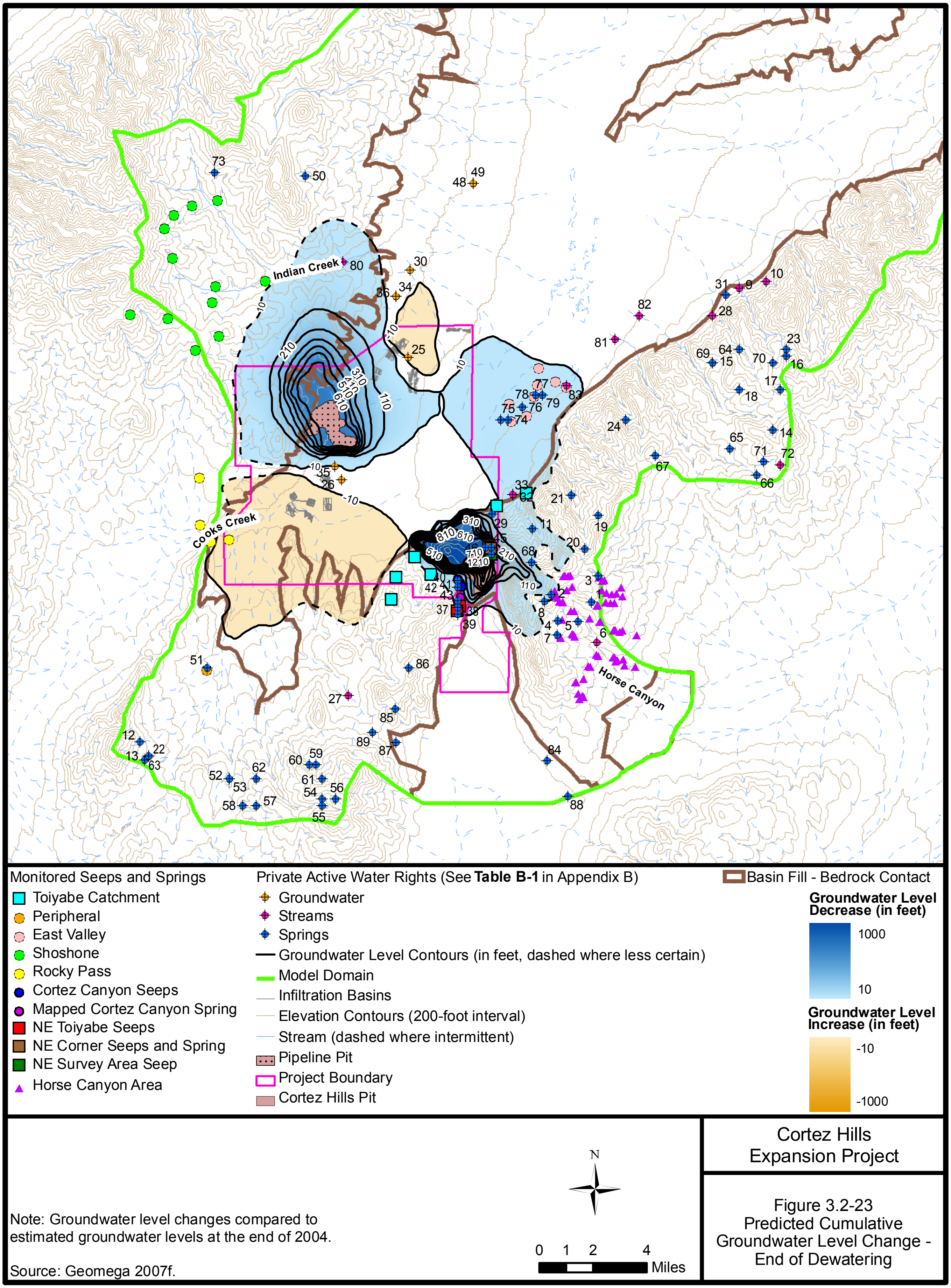
The cumulative effects study area for water resources is the HSA described for the project in Section 3.2.1.1, Hydrologic Setting, and shown in **Figure 3.2-1**, inclusive of the predicted maximum extent of the cumulative 10-foot groundwater drawdown contour. Past and present actions and RFFAs are identified in **Table 2-16**. Of those identified, the actions that have the potential to affect water resources within the HSA include any major groundwater development or dewatering operations that have occurred or are predicted to occur in the reasonably foreseeable future.

CGM's operation in the southern part of Crescent Valley is the only identified project in the cumulative effects study area that has substantial historic or projected future dewatering and water management activities in the HSA. There are other historic and active mining operations within the study area; however, none of these other mines have large-scale dewatering and infiltration activities. In addition, no other major municipal or industrial operations have been identified that impact water resources.

Potential cumulative changes in water levels in the groundwater system were evaluated using the numerical groundwater flow model and impact methodology described in Section 3.2.2.1, Evaluation Methodology. The cumulative effects would include the total drawdown from all past, present, and reasonably foreseeable future mine dewatering and water management activities. For this analysis, this includes historic dewatering activities initiated at the Pipeline Pit in 1996 and continuing through the present and additional dewatering required for the Proposed Action. These rates are presented in **Table 3.2-9** and **Figure 3.2-10**. This cumulative scenario also incorporates future (post-mining) impacts to the groundwater system associated with the development of pit lakes.

The predicted cumulative change in groundwater levels resulting from dewatering and water management activities that were initiated in 1996 and projected future dewatering and water management activities included in the Proposed Action are presented in **Figure 3.2-23**. At the end of dewatering, the cumulative effects are predicted to result in the development of two distinct cones of depression (or drawdown areas): one associated with the dewatering activities at the existing Pipeline Complex, and the other associated with dewatering activities at the proposed Cortez Hills Complex.

The results from the groundwater flow model simulations were used to estimate the maximum extent of drawdown throughout the future mining and post-mining period up to final recovery. The results from the model were combined to illustrate the predicted maximum extent of the area that would be affected by at least 10 feet of drawdown irrespective of time, as presented in **Figure 3.2-24**. The area enclosed within the10-foot drawdown contour would extend approximately 18 miles in a northwest-southeast direction and would encompass portions of the Shoshone Mountains, Crescent Valley, and Cortez Mountains.



Note: Groundwater level changes compared to estimated groundwater levels at the end of 2004.

Source: Geomega 2007f.

Cortez Hills Expansion Project

Figure 3.2-23
Predicted Cumulative Groundwater Level Change - End of Dewatering

06/19/2007

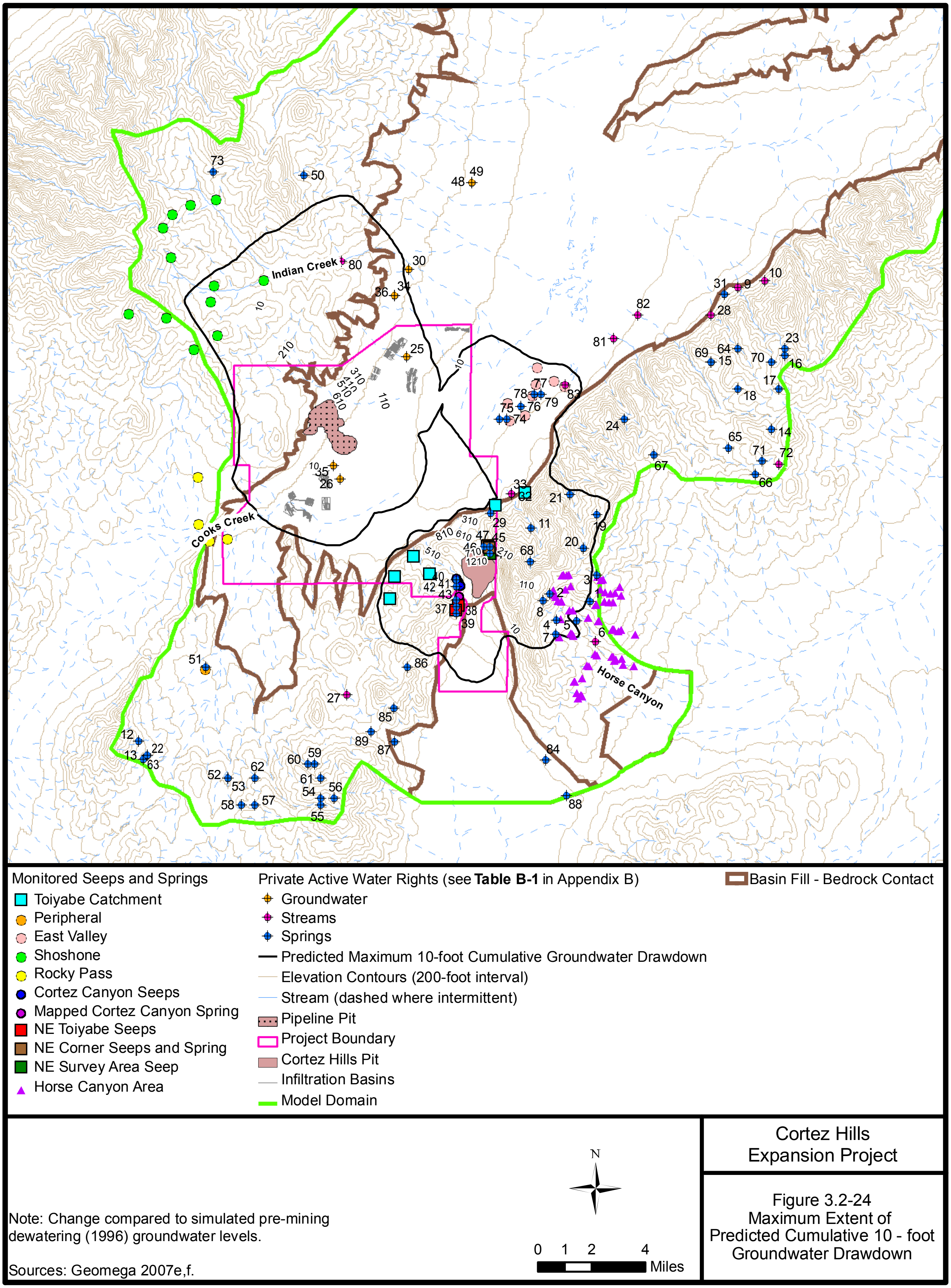


Figure 3.2-24
Maximum Extent of
Predicted Cumulative 10 - foot
Groundwater Drawdown

06/19/2007

Within the predicted cumulative 10-foot drawdown area, there are 53 identified springs and seeps. Of these, 30 springs occur in areas where there would be a potential for drawdown to impact perennial flow (see **Table 3.2-12**; see discussions under Proposed Action, Section 3.2.2.2, and No Action Alternative, Section 3.2.2.4). In addition, 17 of these springs are located in areas where the groundwater levels are not predicted to fully recover within 100 years; flow reduction or flow elimination that occurs in these areas could persist beyond this period. Available information for the Horse Canyon area suggests that springs in this area occur in localized perched groundwater systems that are not interconnected with the regional groundwater system; therefore, impacts to springs within the Horse Canyon area group are not anticipated.

The northwestern margin of the drawdown area is projected to extend beneath the lower perennial stream reaches of Indian Creek and its tributary Feris Creek in the Shoshone Mountains. In addition, the southeastern portion of the drawdown area is projected to extend beneath Mill Creek, a potential perennial reach located in the Cortez Mountains. No other perennial stream reaches are known to occur in the projected cumulative drawdown area. A reduction in groundwater levels potentially could reduce flows and possibly reduce the length of the perennial stream reach. Impacts to other streams in the study area are not anticipated.

Water Quality Impacts

Water quality impacts are not anticipated from pit lakes, waste rock facilities, or process-related components of the existing operations or the Proposed Action.

Water management operations for CGM's operations have included the development of several infiltration basins within southern Crescent Valley. These infiltration basins have been used since 1996 and would continue to be used to dispose of excess mine dewatering water under the currently permitted operations through approximately year 2013. The Proposed Action would extend the use of these infiltration basins for several years. Past infiltration activities have resulted in the increased elevation of the water table (also referred to as a groundwater mound) in the area beneath and adjacent to the infiltration basins. The rising groundwater has caused dissolution of salts present in the vadose zone. These salts were deposited by natural evaporation over a long period of time. The salinity in the groundwater mounds initially is elevated as a result of dissolution of these soluble salts. The high salinity is a transient event; the soluble salts are dissolved in the first few pore volumes of infiltrating water, and additional water does not cause dissolution of substantial additional amounts of soluble salts. The chemistry of the water pumped in the dewatering operations is generally similar to that of the existing groundwater in Crescent Valley. With continued operation of the infiltration ponds, the higher-salinity water presently located below the ponds would mix with the existing groundwater and move down the valley; therefore, the salinity would be reduced by mixing and dispersion. In view of the small volumes of saline water, it is unlikely that the increased salinity would cause exceedances of groundwater quality standards away from the immediate areas of the infiltration basins.

Other Action Alternatives. The total estimated future dewatering requirements under the Grass Valley Heap Leach Alternative and Crescent Valley Waste Rock Alternative would be the same as under the Proposed Action. Therefore, cumulative impacts to water resources would be the same as described for the Proposed Action.

Based on similar drawdown patterns, the cumulative impacts associated with dewatering for the Cortez Hills Complex Underground Mine Alternative are expected to be similar to the Proposed Action. Therefore, potential cumulative impacts to perennial springs, streams, and groundwater resources would be the same as under the Proposed Action.

Under the Cortez Hills Complex Underground Mine Alternative three pit lakes would develop (i.e., Gap and Crossroads pit lakes at the Pipeline Complex, and the Cortez Pit lake in the Cortez Complex). Therefore, the evaporative loss from the pit lakes would be less under this alternative than for the Proposed Action, which includes one additional pit lake (Cortez Hills Pit). The potential for water quality impacts would be similar for all action alternatives.

3.2.4 Monitoring and Mitigation Measures

Issue: Mine-induced drawdown of groundwater levels could impact flows in Mill Creek and identified springs and seeps located within the area affected by drawdown.

Mitigation Measure WR-1a: CGM would develop a comprehensive water resources monitoring plan to identify potential impacts to perennial surface water resources and groundwater resources within the projected mine-related 10-foot groundwater drawdown contour. CGM would be responsible for continued monitoring and reporting of changes in groundwater levels and surface water flows prior to, and during, operation and for a period of time in the post-reclamation period. The plan would include the following:

1. Investigate sources of recharge to determine if mine-induced dewatering would affect flows.

2. Seasonal monitoring of flow at two locations along perennial reaches of Mill Creek.

3. Installation of monitoring wells in the vicinity of Mill Creek to monitor changes in groundwater elevations over time in the vicinity of this surface water resource.

4. Monitoring of these new surface water stations, and of spring and seep sites currently monitored for CGM's existing operations, would include annual flow measurements during the low-flow season (late September through mid- October). The depth of groundwater also would be monitored on a quarterly basis.

CGM would provide the results of water level monitoring, describe any deviations from the original predictions, evaluate if changes in flow are attributable to mine-induced drawdown, and propose modifications to the monitoring plan, as necessary, in an annual report to the NDWR and the BLM. The combined surface and groundwater monitoring results would be used to trigger the implementation of Mitigation Measure WR-1b to mitigate impacts to water resources, if applicable. Monitoring and reporting would continue until impacts to water resources have been mitigated.

Effectiveness: This measure would provide for identification of potential flow impacts to perennial surface waters as a result of mine-related groundwater drawdown and a trigger for development of appropriate mitigation.

Mitigation Measure WR-1b: If monitoring (WR-1a) indicates that flow reductions in perennial surface waters within the projected mine-related 10-foot groundwater drawdown contour are occurring and that these reductions are likely the result of mine-induced drawdown, the following measures would be implemented:

1. The NDWR and the BLM would evaluate the available information and determine if mitigation is required.

2. If mitigation is required, CGM would be responsible for preparing a detailed, site-specific plan to enhance or replace the impacted perennial water resources. The mitigation plan would be submitted to the NDWR and BLM identifying drawdown impacts to surface water resources. Mitigation would depend on the actual impacts and site-specific conditions and could include a variety of measures (flow augmentation, on-site or off-site improvements). Methods for providing a new water source or improving an existing water source may include, but are not limited to:

    - Installation of a water supply pump in an existing well (e.g., monitoring well);
    - Installation of a new water production well;
    - Piping from a new or existing source;
    - Installation of a guzzler;
    - Enhanced development of an existing seep to promote additional flow; or
    - Fencing or other protection measures for an existing seep to maintain flow.

3. An approved site-specific mitigation plan would be implemented followed by monitoring and reporting to measure the effectiveness of the implemented measures. If initial implementation were unsuccessful, the NDWR or BLM may require implementation of additional measures.

Effectiveness: Feasibility and success of mitigation would depend on site-specific conditions and details of the mitigation plan.

Issue: Mine-induced drawdown potentially could reduce flow at the point of divergence for surface water rights, or reduce water levels in water supply wells.

Mitigation Measure WR-2: CGM would be responsible for monitoring groundwater levels between the mine and water supply wells, groundwater rights, and surface water rights within the projected mine-related 10-foot groundwater drawdown contour as part of the water resources monitoring program (Mitigation Measure WR-1a). Adverse impacts to water wells and water rights would be mitigated, as required by the NDWR.

Effectiveness: Implementation of this mitigation measure should mitigate adverse impacts to water rights.

Issue: Placement of waste rock facilities within the FEMA-designated flood hazard Zone A in Crescent Valley could exacerbate potential flood conditions and related damages.

Mitigation Measure WR-3: CGM would work with state and county FEMA representatives and with other state or federal agencies, as appropriate, to design the Pipeline Waste Rock Facility expansion area, CR 225 reroute, and (if the Crescent Valley Waste Rock Alternative is selected) the Crescent Valley Waste Rock Facility to safely convey the 100-year, 24-hour flood event through or around the project area with minimal or no hazard to human life, property, or project components. A shorter duration flood event (e.g., 6 hours) or an appropriate rain-on-snow event may be selected as the project design flood if a larger peak discharge and/or a longer flood hydrograph duration would result. Flow conveyance structures and project component configurations would be such that stream and floodplain stability would be maintained or enhanced, and erosion and sedimentation would be avoided or minimized.

Effectiveness: Implementation of this mitigation measure should mitigate the potential impacts of floodplain obstructions on flow depths and velocities and should minimize the increases in flood damages that otherwise could result from the placement of waste rock in the flood hazard zone.

Issue: Long-term overtopping or infiltration through the bed and sideslopes of the stormwater diversion along the east side of the proposed Cortez Hills Pit could contribute to instability of the pit wall in that locale. Failure of diversion outlet features over the long term would lead to accelerated erosion downgradient of the diversion.

Mitigation Measure WR-4: Prior to final reclamation, CGM would work with federal and state agency representatives to design and construct a stormwater diversion system along the east side of the Cortez Hills Pit that would route runoff away from the pit wall over the long-term with little or no maintenance, and adequately control flow velocities so as to prevent outlet failure and resulting accelerated erosion. Such design and construction safely would accommodate flow from a reasonable runoff event selected in cooperation with state and federal agencies. Methods to minimize seepage and infiltration (e.g., a compacted clay layer protected by adequately-sized durable riprap) would be incorporated into the design and implemented during construction of the diversion. No embankments would remain as outlet structures; all outlet features would be designed and constructed to minimize erosion and provide energy dissipation (e.g., installation of shallow excavated basins with outlets on grade with the existing land surface in combination with rock riprap).

Effectiveness: Implementation of this mitigation measure should mitigate the potential for impacts from stormwater-related contributions to pit wall instability and accelerated erosion downgradient of the diversion system.

3.2.5 Residual Adverse Effects

An area of residual mine-related groundwater drawdown is predicted to persist for the foreseeable future around the mine as shown in **Figure 3.2-14**. Successful implementation of mitigation measures would minimize or eliminate most residual adverse effects to water resources. However, a permanent reduction of surface discharge associated with drawdown potentially could occur and would comprise a residual adverse effect to individual surface water locations, but would have little effect on the overall water balance of the hydrologic basins.